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What European Car Designers Are Doing Today

By Maurice Platt
Technical Editor, *The Motor*, England

OUTSTANDING features shared by the new British and Continental cars alike are restrained streamlining and wider seating. There has been a definite reaction from the advanced aerodynamics of a year ago but the ebb of that tide has left valuable and permanent results in smoother contours, roomier interiors, inter-axle seating, in-built luggage compartments and the partial or complete enclosure of the spare wheel.

Four-door saloons predominate but the vogue of the all-weather body is becoming quite important except, perhaps, in France. In Germany the cabriolet style, with four doors, steel-framed drop windows and a quick acting fabric-covered folding head, is very popular. In Great Britain similar "custom" coachwork is built by Salmon (Tickford head), Martin Walter and others; it is listed on many popular chassis. The foursome drop-head coupe, normally seating two people but with room for two more passengers at the back if need be, is increasingly in demand. Even the open tourer, with folding hood and side curtains, has experienced a mild revival owing to the increasing sales of open sports cars. Nearly all the saloons sold in England still have a sliding roof.

Independent front springing was the talk of the London Show owing to its very recent adoption by Rolls-Royce, Humber and Hillman. It has been used for a year or more by Alvis, Singer, Vauxhall and B.S.A. On the Continent the independent system "arrived" some time ago and is employed by several makers (particularly the Germans) for the rear wheels as well as those at the front. While independent front springing is now used by concerns with large outputs such as Vauxhall, Opel, Auto Union, Citroen, Peugeot and Fiat, the rigid axle is retained by Morris, Austin, Renault, Standard, Wolseley and many other big producers.

The chief mechanical innovation at the Paris Salon was the Cotal electro-magnetic epicyclic gearbox. After many years of development this transmission has been adopted by various important concerns such as Peugeot, Salmson, Delage,

Presented in part before Montreal Regional Meeting, Nov. 25, 1935, by John A. C. Warner in the absence of the author.

At Paris (left) and at London (right) Continental and British automobile manufacturers showed the latest results of their design efforts

Chenard et Walcker, etc. Further references are made to it in the section of this review allocated to transmissions.

Before discussing these and other trends in greater detail it seems desirable to provide some indication of the importance of the concerns which will be named. In some cases such as Rolls-Royce, Alvis, Hotchkiss and Mercedes-Benz the output is not large but the prestige of the firm is such as to lend special significance to its engineering activities. In other cases volume is the chief consideration and the names of the really big European producers are all world-known. Between these extremes there is a number of interesting cars made in medium quantities to individualized designs. The relative "volume importance" of these firms is difficult to assess because production figures are not public; neither are shrewd guesses encouraged.

My plan is therefore to grade these concerns into the following categories with the proviso that the figures are merely estimates:

Classification of Outputs

Class	*Estimated annual output*
A	50,000 to 100,000
B	20,000 to 35,000
C	5,000 to 15,000
D	Those well below 5,000

There are gaps in this classification but nearly all our car production units will be found to fit one or other of the groups specified. These class letters (A, B, C, D) will be used in this review wherever reference to output seems desirable.

A valuable indication of the sizes of automobile popular in Great Britain is contained in the figures for new car registrations published monthly. The horsepower ratings are by the R.A.C. formula ($D^2N/2.5$). The actual figures for 1934 (annual totals) are as follows:

New Car Registrations (Great Britain) 1934

Class	*Total*	*Percentage of grand total*
6 - 10 hp.	130,377	57½
11 - 14 hp.	51,069	22½
15 - 21 hp.	33,748	15
over 21 hp.	11,437	5
Grand Total	226,631	100

Inquiries made through correspondents of *The Motor* in France and Germany failed to produce detailed figures to show the relative popularity of various car sizes in these countries. The respective governments have both abandoned taxation on horsepower in favor of a fuel tax but the new system is no more favorable to the high-powered car than the one which it has replaced. On the other hand lengthy stretches of straight roads and long distances favor the use of powerful cars on the Continent to a greater degree than in England. Total production of automobiles during 1934 was 164,000 in France; 147,330 in Germany. About 85 per cent of the German output consists of cars of less than 2 liters capacity.

The big producers—Renault, Peugeot, Citroen, Opel, Auto Union and Fiat—all appear to concentrate on cars of 2 liters capacity or less for series construction but also make larger models in more limited quantities.

Four-cylinder cars outsell all other types in Europe by a comfortable margin. Six-cylinder models range in engine capacity from 1½ liters upwards and the straight eight is built by a number of Continental constructors but by only one British maker.

The following table is based upon an analysis of four popular types of British car and is extracted from a paper which the writer recently prepared for the Institution of Automobile Engineers. The cars described account for something like 161,000 sales out of the total of 226,631 cars sold in Great Britain during 1934. The prices quoted are for fully equipped saloon models.

No. of cylinders	4	4	6	6
Rating (R.A.C.), hp.	9-10	12	12-14	16-20
Capacity cc. — Maximum	1,343	1,669	1,783	2,663
Capacity cc. — Minimum	933	1,452	1,378	2,110
Capacity cc. — Average	1,155	1,555	1,590	2,280
Stroke/bore ratio	1.4-1.7	1.4-1.6	1.5-1.6	1.4-1.6
Gear ratios — Top, minimum and maximum	5.2-5.6	4.9-5.5	4.8-5.5	4.7-5.5
Gear ratios — Top, average	5.43	5.2	5.33	5.1
Gear ratios — Third speed	7.9-8.4	7.3-8.0	7.2-8.5	6.5-8.2
Average tire dia., in.	27	28	28	28.5
Road speed (m.p.h.) at 3,000 (engine) r.p.m.—on top gear	44.5	48.2	47.0	50.2
Unladen weight, lb.	1,910	2,530	2,460	3,100
Wheelbase, minimum and maximum	7' 3"-8'	8' 2"-8' 10"	8' 5"-9'	9' 2"-10'
Track, minimum and maximum	3' 9"-4'	4'-4' 4"	4'-4' 4"	4' 8"-4' 9"
T. circle, minimum and maximum diameter	30'-38'	35'-40'	35'-40'	38'-45'
Price range, saloon de luxe, £	140-180	200-335	200-250	300-500

The following examples of Continental practice in three representative cars produced in large numbers are quoted for comparative purposes; each is a four-cylinder model:

Make of Car	Citroen (*Front Drive*)	Renault	Opel
Rating (R.A.C.), hp.	12.8	12.1	11.3
Engine capacity, cc.	1,628	1,463	1,279
Stroke/bore ratio	1.4	1.35	1.33
Gear Ratios: Top	4.9	5.2	5.14
Middle	8.3	9.2	......
Tire Size	140 x 40	4¾ in. x 18 in.	5¼ in. x 16 in.
Unladen Weight, lb.	2,020	2,460	......
Wheelbase	9 ft. 6½ in.	8 ft. 8 in.	8 ft. 1½ in.
Track	4 ft. 4 in.	4 ft. 4 in.	3 ft. 10 in.
Turning Circle	45 ft.	36 ft.	37½ ft.
Approximate Price of Saloon, in francs	19,000	17,000	......

One other generality may be permitted before turning to a more detailed account of chassis and coachwork features. This is the extent to which British makers of popular cars have adpoted the practice of offering engines of alternative size in a single chassis. The plan is often extended by using a single saloon body type on two or more chassis differing in wheelbase. Thus four models of the Morris Series 11 six-cylinder range are available, with engines rated at 16, 18, 21 and 25 hp., with one saloon body used throughout. The 16 hp. and 18 hp. engines are employed in a chassis of 117 in. wheelbase and the larger engines in a chassis of 121½ in. wheelbase. Modified gear ratios constitute the only other differences in specification. Austin, Hillman, Humber, Vauxhall, Standard and Wolseley provide further examples.

Engines

The technical interest of an engine is apt to be in inverse ratio to the volume in which it is produced. Units built in large numbers and at low cost conform to a simple pattern which is much the same irrespective of their country of origin. Leaving these for later consideration we will take a

look at some new engines from plants which produce specialized cars of medium and high price.

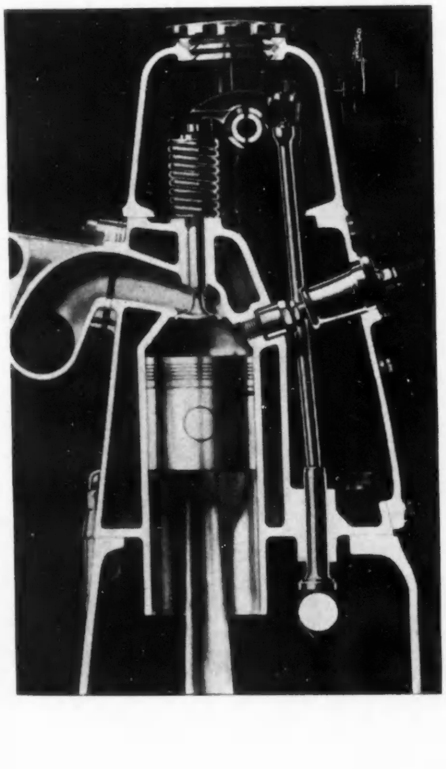
Up to a year ago British makers of this class were all building six-cylinder engines. This position has been altered by the recent introduction of a V-12 Rolls-Royce (D), a V-8 Riley (C) and two straight-eight Daimler models (C). The Daimler "Double Six" Vee engine, although dating back to 1926, was produced only for a few exclusive chassis such as those ordered by Royalty.

In the Rolls-Royce Phantom III engine a single casting is used for the crankcase and cylinder jackets, the latter being fitted with wet liners. Cylinder heads are of aluminum and carry push-rod operated valves with rocker clearances hydraulically controlled. Four downdraft carburetors are fitted between the cylinder banks. The Vee angle is 60 deg. An interesting detail is the use of three oil relief valves to control pressures. The crankshaft is fed at 50 lb., the valve gear at 10 lb., and the timing gear at 1¾ lb. under normal running conditions. Cylinder dimensions are 82.5 mm. by 114 mm. (7338 cc.); the crankshaft runs in seven bearings.

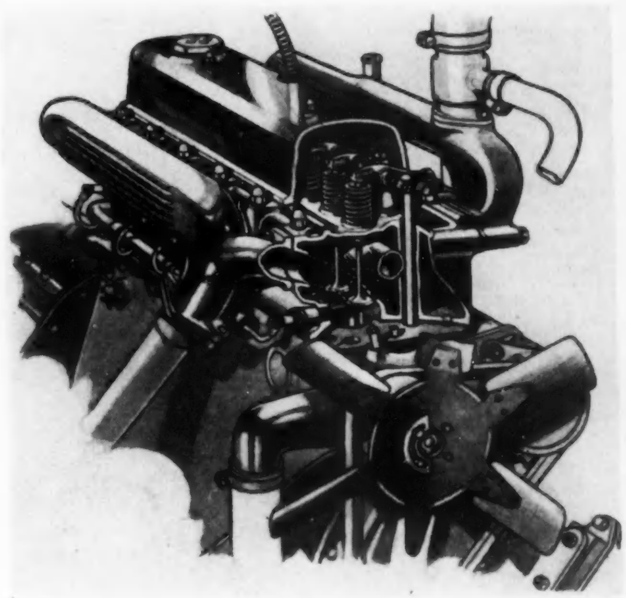
The new Riley engine is a 90 deg. V-eight with a three-bearing crankshaft. Riley cars are of the high-performance sports type and, following the previous practice of this concern, the valves are inclined in hemispherical combustion chambers. They are operated by rockers and push-rods from three camshafts. Two downdraft carburetors are mounted between the cylinder blocks and the exhaust manifolds are located on the outside. Cylinder dimensions are 60.3 mm. by 95.2 mm. (2178 cc.).

The Daimler light straight-eight has a cylinder capacity of 3.4 liters (72 mm. by 105 mm.) and the outstanding constructional feature is the formation of cylinder block and head in a single iron casting. This return to the integral head eliminates gasket troubles and, by doing away with studs and their attendant bosses, facilitates the provision of adequate water spaces and reduces risk of distortion.

The crankcase is a deep casting of aluminum alloy, the joint between this unit and the block being fairly high up. The valves are placed vertically in the head in combustion



The integral head principle as used in certain Daimler and Lanchester engines. Block and head form a single iron casting, bolted to an aluminum crankcase, and carry the complete valve gear.



Cross-section of the new 2½-liter six-cylinder SS engine with ports designed under Weslake patents. Two carburetors deliver mixture to a longitudinal passage cored in the cylinder head.

chambers with sloping walls. Rockers, push-rods and tappets are all carried by the block-head casting and are detached therewith as an assembly when this casting is lifted for decarbonizing. With special equipment this job takes but little more time than the lifting of a detachable head and has the advantage of exposing the pistons and rings.

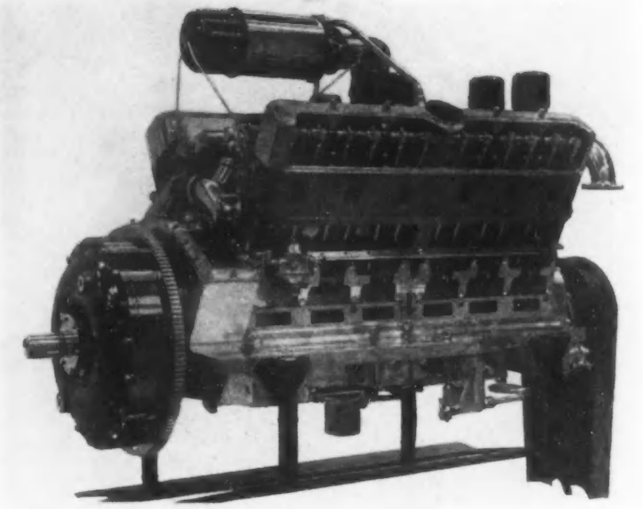
This integral principle was introduced in the 18 hp. Lanchester (made by an associated company) nearly a year ago and has given good results in service.

Because it is kind to bearings and oil temperatures the separate alloy crankcase is also favored by builders of high performance sports cars which are ordinarily driven hard. In the Alvis (D) six-cylinder models alloy steel bolts securing the main bearing caps pass through the crankcase and have collars recessed into its top surface. Each bolt is extended above the collar to pass through the bottom flange of the cylinder block and so forms a direct tie between block and bearing.

On the Continent the only V-12 engine is the Hispano-Suiza (D) with separate cast-iron blocks set on an aluminum crankcase. Bore and stroke are exactly equal (100 mm.). The central European firm of Tatra produces a V-eight air-cooled engine with blower supplying air through ducts to finned cylinders. Ford (A) produces the well known 30 hp. V-eight model at the Dagenham factory (near London) and has recently added a 22 hp. series with the same chassis and coachwork. This smaller V-eight engine is built on just the same lines as the 30 hp. type but the cylinder capacity shows a reduction of 38½ per cent.

Under the name of Matford these models are produced in France (C) in a big plant at Strasburg acquired from Mathis not long ago. Big sales are predicted for the 22 hp. model in France as it attracted great interest at the recent Paris Salon.

The only Continental maker building straight-eight cars on series production lines is Renault (A), the engine being a conventional L-head unit of 5½ liters capacity. Straight-eight models are however built in limited numbers (D) for the high-priced field by Bugatti, Delage, Alfa Romeo, Mercedes-Benz, Minerva, Austro Daimler and Isotta-Fras-



The Daimler Double-Six engine and fluid flywheel as employed in the Royal cars supplied to T. M. The King and Queen.

chini. The last-named (Italian) firm claims to have been the first in the world to produce this form of engine commercially.

Another interesting Italian production is the Lancia narrow-Vee engine built with four and eight cylinders. In each case all the bores are formed in a single block but are angled and staggered to reduce the length and weight of the unit. The stroke-bore ratios are low—1.1 in the four-cylinder engines and 1.2 in the "eights".

Sports car engines hold an important place in the European picture partly because of a leadership in design, resulting from limited production (D) and racing experience, and partly owing to the prestige and publicity which they enjoy. These cars are of two kinds. The most popular, selling at moderate prices, are virtually specially tuned touring models with high-lift camshafts, abnormal compression, polished ports, stiffened valve springs, etc. The other kind of sports car is a detuned racing job with overhead camshafts such as is sold by M.G., Alfa Romeo, Bugatti, Aston Martin and Fraser Nash. Superchargers are fitted in certain instances but this field is looked after mainly by certain firms such as M. A. McEvoy, Ltd., who supply superchargers which can readily be fitted to selected engines by enthusiastic owners.

A point of interest in many types of sports car is the popularity of multiple carburetors. These engines are mainly of the six-cylinder type with push-rod operated overhead valves. Two carburetors are used by S.S., Hotchkiss, M.G. (for a new 2-liter model) and Bentley; three instruments are employed by Alvis.

The 2½-liter S.S. engine is specially built for the S.S. company (D) by the Standard company. Push-rod operated overhead valves are used and the porting is designed under Weslake patents. Henry Weslake is a consulting engineer who has developed an air flow experimental technique which has resulted in some rather remarkable information regarding the best proportions for passages, ports and valves. Bench tests of the new S.S. engine show an output of 103 b.hp. at 4400 r.p.m. from a cylinder capacity of only 2.66 liters. The brake mean effective pressure rises from 113 lb. per sq. in. at 1000 r.p.m. to a peak value of 132.5 lb. at 2000 r.p.m. At maximum brake mean effective pressure the fuel consumption is given as 0.53 pints (say 0.5 lb.) per b.hp. per hour.

Two horizontal carburetors feed the mixture into a passage running the full length of the cylinder head and cored therein. From this passage six curved ports lead directly to the inlet valves. Somewhat similar ports take the burned gases to a six-branch exhaust manifold bolted to the opposite side of the head. There is no hot spot.

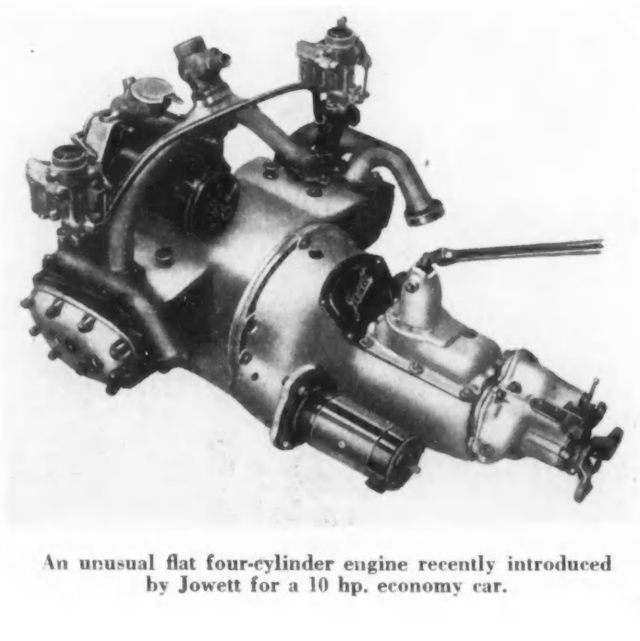
In writing of experimentalists, mention must be made of the remarkable work which has been done by R. C. Cross from which practical results will follow on a commercial scale before long. He has developed a rotary valve in a way which has overcome the old difficulties of adequate lubrication and gas tightness. Owing to the absence of hot poppet valves, compression ratios as high as 12 to 1 have been used successfully with ordinary fuels and the writer has seen a Cross engine developing a brake mean effective pressure of 145 lb. per sq. in. at 6500 r.p.m.

In the latest Cross engines the rotary valve is fitted to a bushing in a split housing. The valve is cylindrical and runs the full length of the engine; it contains ports which register at appropriate intervals with rectangular openings cut in the bushing. One such opening is located above each cylinder and the surrounding edges of the bushing are tapered in thickness and are left unsupported over a narrow margin. The springy action which results provides the gas seal. By making these openings slightly smaller than the inlet ports and slightly larger than the exhaust ports their edges are cooled by the mixture and are protected from the exhaust gases. The valve turns freely, with a controlled clearance, at all working temperatures.

In the course of his experiments Mr. Cross has also succeeded in running an aluminum alloy piston (with wide iron wearing rings) in an aluminum alloy cylinder. This unconventional plan has obvious advantages and has given good results under prolonged tests. It has also been used with success in record-breaking motorcycles.

Sleeve valves of the Knight type are now employed only by Minerva, Panhard and Voisin; in each case production is limited. Daimler finally relinquished the sleeve valve, even for the Double Six engine, over two years ago.

The leading exponent of supercharging is Mercedes-Benz, a Roots type blower being used in the 5-liter straight-eight model. This engine has push-rod operated overhead valves.



An unusual flat four-cylinder engine recently introduced by Jowett for a 10 hp. economy car.

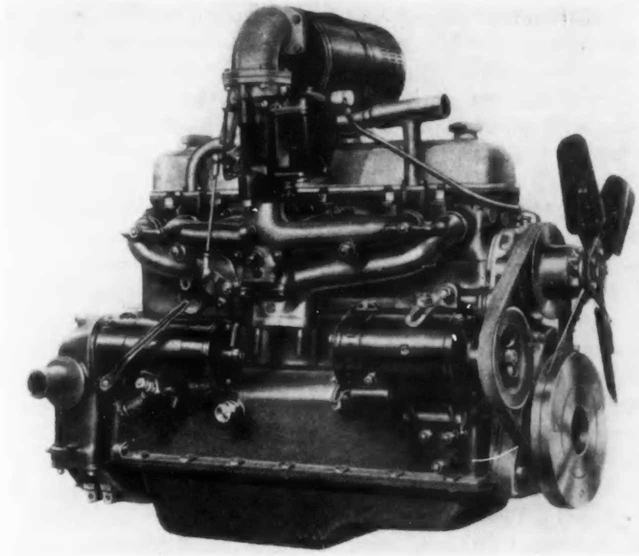
In the Mercedes system of supercharging the blower is brought into action only when a full depression of the accelerator engages a clutch. At full throttle a stiff spring provides a check to further pedal movement so that the driver has to exert excess pressure deliberately in order to bring the supercharger into action. The design involves certain complexities in the fuel and intake systems to allow the carburetor to change over from atmospheric induction to a supply of air under pressure.

Two-stroke engines are used in Germany to a certain extent for small economy cars and the same principle has been employed by Zoller for a supercharged racing engine. A good example in the former class is the D.K.W. front-drive runabout built by the German combine known as Auto Union. The two-cylinder engine is mounted transversely with a chain drive from the crankshaft to a gearbox bevel-drive unit placed alongside and in front of the crankcase. This little car, with cabriolet body, sells at a very low price. The engine capacity is only 584 cc.

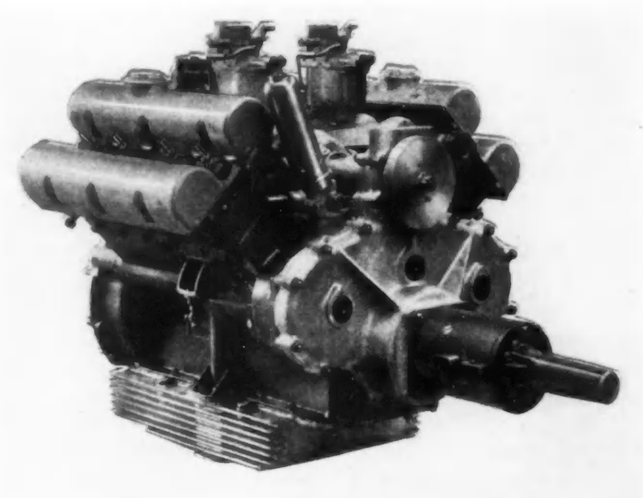
In England the rear engined Trojan (D) has for some time provided the only example of two-stroke practice. It has recently been redesigned in six-cylinder form under the name of Mastra. The cylinders are in two parallel rows with each pair sharing a combustion chamber. Corresponding pairs of connecting rods form a one-piece Vee forging and use the same crankpin. This gives the pistons a differential motion which enables exhaust ports in one cylinder to be uncovered slightly before the inlet ports in the paired cylinder. Rods are springy enough to allow for the slight changes in distance between gudgeon pins.

Another interesting British introduction is the Jowett "flat four"—a 10 hp. four-stroke engine built by a firm formerly specializing in two-cylinder economy cars and light goods vehicles (C). The four cylinders of the new model are horizontally opposed and each pair is fed by a separate carburetor. The total capacity is 1166 cc.

The four-cylinder engine of small size which is the staple product of the larger European factories displays a standardization of design very different from the diversity of types found in larger and more costly models. British, French, German and Italian "small fours" produced in Class A and B quantities are all of the L-head type with the exception of Citroen who adopted push-rod operated overhead valves for the front-drive series initiated nearly two years ago. Owing to the superior economy of the four-cylinder engine it is also used up to relatively large capacities in countries with a heavy fuel tax, such as France. An example is the 17.9 hp. Renault with 2.38 liters of swept volume.



The new six-cylinder 1½-liter Fiat engine which is typical of sound Continental practice in medium-priced chassis. The overhead valves are operated by push rods. Note the unusual 3-point mountings.



The 18 hp. Riley V-8 engine which is used in conjunction with a centrifugal clutch and an epicyclic self-changing gearbox of the Wilson type.

Crankcase and cylinder block are invariably formed from a single iron casting which carries three main crankshaft bearings. These are usually bronze shells, lined with white metal, although steel-backed bearings are now making an appearance. Detachable cylinder heads show a considerable variety in shape with a general tendency to concentrate the volume over the valves and to place the sparking plug toward the exhaust side.

Downdraft carburetion is general, with a two-branch inlet manifold serving paired valve ports. This is usually cast in one piece with the exhaust manifold. The camshaft runs in three bearings (often directly in the iron crankcase) and is usually driven by twin roller chains without means of adjustment. In some cases, notably Morris (A) and Austin (A), the dynamo is carried by a cradle on the cylinder head with the fan mounted on the armature spindle. The belt drive is tensioned by an eccentric or pivoted cradle mounting. With this scheme thermo-syphon water circulation is used, making a pump unnecessary. The popular alternative is to build a fan and impeller as a unit which is bolted to the front end of the cylinder block. A single belt drives this unit together with a dynamo mounted alongside the block.

A transverse steel plate, bolted between the timing gear cover and the crankcase at the front, extends sideways to two rubber-insulated supports carried by the frame side members in Austin (A), Morris (A), Standard (B), Hillman Minx (B) and other small engines. The third support, also rubber-insulated, is usually located at the back of the gearbox. Citroen is the only maker using the true "floating power" system under Chrysler license. The new 1½-liter Fiat (six-cylinder) engine displays the unusual plan of a low single-point support at the front and two trunnion mountings placed one at each side of the clutch housing.

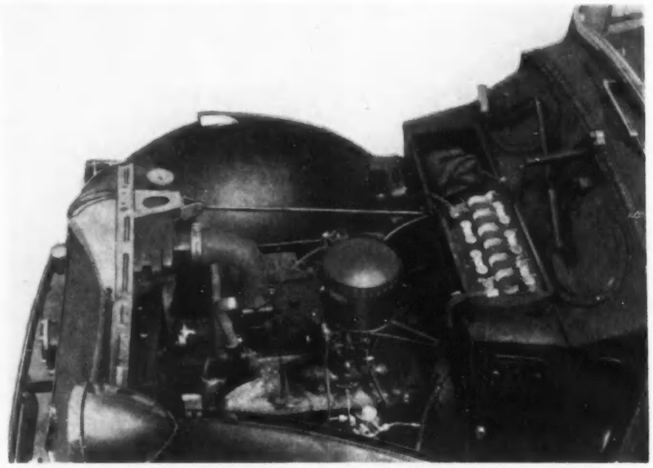
Small and medium-sized six-cylinder engines for low-priced cars follow similar lines but push-rod operated overhead valves are relatively much more popular. Aluminum heads are coming into fashion for L-head engines of this class, whereas iron heads are the rule for the small "fours". Compression ratios range around 6 to 1 for iron and 7 to 1 for aluminum. No choice of ratios is offered by European makers. Four main bearings and counterbalanced crankshafts are used in the six-cylinder types and in a few cases connecting rods are drilled to take oil to the gudgeon pins. Aluminum alloy pistons are universal, carrying three or four rings. White metal for the big end is often cast directly into the steel rod.

Cylinder wear has caused a certain amount of trouble in small-bore engines, creating difficulties with car owners when it exceeds a rate of 0.001 in. per 1500 miles. Chromium iron blocks, harder alloy pistons, a great variety of rings and drilled connecting rods (to improve piston lubrication) are among the palliatives. With the same incentive various kinds of bore finishing processes have been tried; fine boring with a free-cutting tool, slow feed and high cutting speed is probably the method most widely used. Some makers follow this by honing or lapping while others allow running-in to produce the polish.

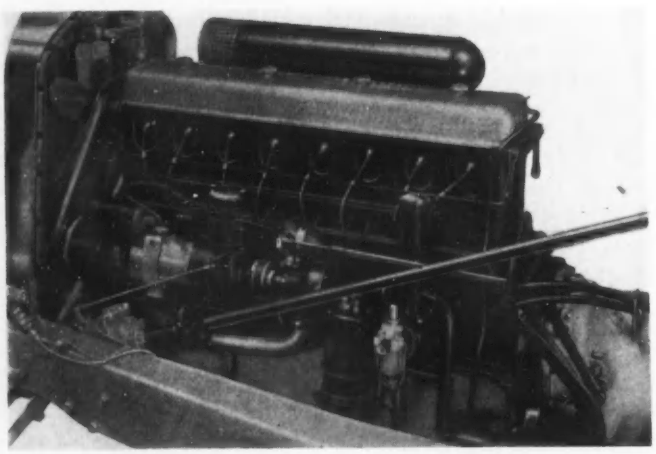
The I.A.E. research which showed bore wear to be greatly accelerated by low cylinder wall temperatures has resulted in the general use of thermostats and in more foolproof starting devices.

Cylinder liners made from centrifugal castings are widely used in commercial vehicle engines but are employed by very few car makers. Citroen (B) uses them in four-cylinder engines, these being wet liners flanged at the top and held by the cylinder head. Wet liners are fitted to the new twelve-cylinder Rolls-Royce. In the Siddeley Special (D) and A.C. Ace (D)—both of which are six-cylinder overhead valve models built for a limited market—wet iron liners are used in an aluminum block. The Siddeley Special also has an aluminum head with inserted valve seatings. Such seatings are as yet rare in European engines but are used in the new six-cylinder Humber series.

Battery and coil ignition is used on a large proportion of European engines but the magneto has had a small revival in sports cars owing to the development of compact vertical types such as the Scintilla Vertex. In coil systems automatic timing is fairly general but only a few makers employ suction control as an addition to a centrifugal governor.



Typical of British light car design—the 10 hp. four-cylinder Standard engine, also showing the mounting of the battery and toolbox in the dash under the bonnet.



The Mercedes-Benz five-liter straight-eight showing the layout of the auxiliaries. Manifolds and a supercharger are mounted on the opposite side.

Air intake and exhaust silencing have received a great deal of attention during the past two years. Developments in this connection have followed lines well known to American engineers.

As an alternative to the A.C. fuel pump (made in an English factory) many British car makers use the S.U. electrical pump. In this device a diaphragm is solenoid operated, the circuit being inter-connected with the ignition switch.

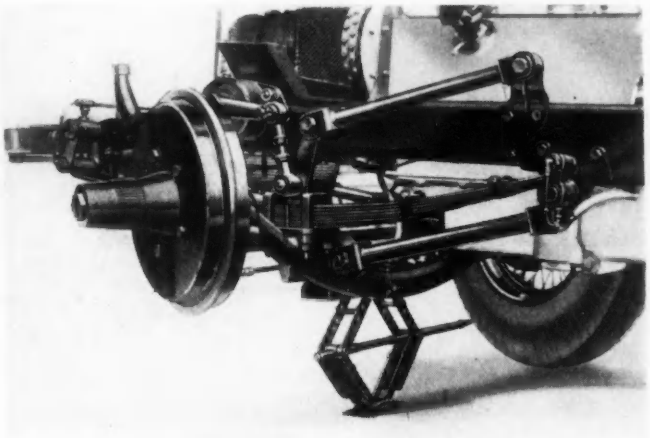
Suspension Systems

Anyone who has done much driving on the Continent will appreciate the reason for the lead taken by German and French designers in the development of suspension systems. Even today, apart from the Italian autostradas and a few trunk roads in other countries (notably Germany), the general standards of highway maintenance are far below those ruling in England.

Pioneer chassis built in small numbers such as the Sizaire and the Cottin Desgouttes, were exhibited at the Paris Salon with independent suspension all round as far back as 1924. It was not until the Salon of 1932 that young M. Dubonnet showed a chassis specially built to demonstrate his unique suspension which has since been adopted by Vauxhall (B) in England, Opel (A) in Germany and by Fiat in Italy for a new 1½-liter chassis. The Vauxhall and Opel companies are both associated with General Motors.

In Germany the writer remembers the sensation created by the appearance of Mercedes-Benz chassis with independent suspension by coil springs at the Berlin Show of February, 1932. This concern favors independence all round. At the back the final drive casing is mounted on the frame and provides bearings for trunnions which carry an axle tube at each side. Between each cross shaft and the differential unit there is a ring-type universal joint, located in line with the corresponding trunnions.

"Swing-Axles," as they call them, are very popular with other German constructors. A good example is the six-cylinder 3½-liter Maybach introduced last February. Here a transverse leaf spring is employed, mounted fairly high, the ends of which are connected to pivoted axle tubes through coil springs. A similar combination of springs is employed at the front in conjunction with transverse radius arms.



Front axle controlled by radius arms on the Daimler Light Twenty with semi-elliptic springs shackled at both ends. The D.W.S. permanently fitted jack is shown in the extended position.

Transverse leaf springs are employed to give independent suspension at the front and back in many other German cars, such as the Hansa (C) and the Praga. The B.M.W. has a similar suspension at the front but a conventional back axle is employed with semi-elliptic springing. In the Wanderer, built by Auto Union (B), the front suspension is conventional but "swing-axles" are used at the back. The big straight-eight Horch from the same factory has independent transverse front springing. At the back, the wheels are coupled by a light axle tube (with conventional springing) but are driven by cardan shafts from a differential mounted on the frame. The sole advantage would appear to lie in reducing unsprung weight.

Front-drive models enjoy a considerable vogue both in France and Germany and this principle is always combined with independent front springing. In the German Adler, Audi and D.K.W. front-drive chassis transverse leaf springs are employed; they are also used in the one British example: the B.S.A.

Although the torsion bar spring originated in Germany its outstanding exponent is Citroen (B) who uses it in the 12 hp. and 15 hp. front-drive cars. Each steering head is carried by triangulated radius arms and the lower one of each pair is connected by a dog coupling to a torsion bar running alongside the engine. Torque reaction at the rear end of each bar is taken by a lever (carried by the bar) which makes contact with a screwed stop. These stops provide an adjustment for leveling the car after assembly. The rear wheels are carried on a light trailing axle and are sprung by transverse torsion bars.

Of the other big French producers Peugeot (B) continues to employ the independent front suspension adopted some three years ago (transverse semi-elliptic above long radius arms) in conjunction with conventional rear springing, while Renault (A) uses rigid axles at both front and rear. The Renault front suspension is by semi-elliptics located in orthodox fashion, but at the back a transverse leaf spring is used, anchored to a tubular cross-member at the center and shackled to the axle at each end. To reduce the height of the frame the spring is located behind the axle. This plan is used in conjunction with a torque tube; diagonal bracing rods extend from the front end of the torque tube to the outer ends of the axle case.

Most of the Continental builders employ hydraulic shock absorbers. In a few cases, such as Hispano-Suiza and Bugatti, the Repousseau scissor-type friction damper is employed with a mechanical hook-up to adjusters on the steering column. In this way the damping of the front and rear pairs can be varied.

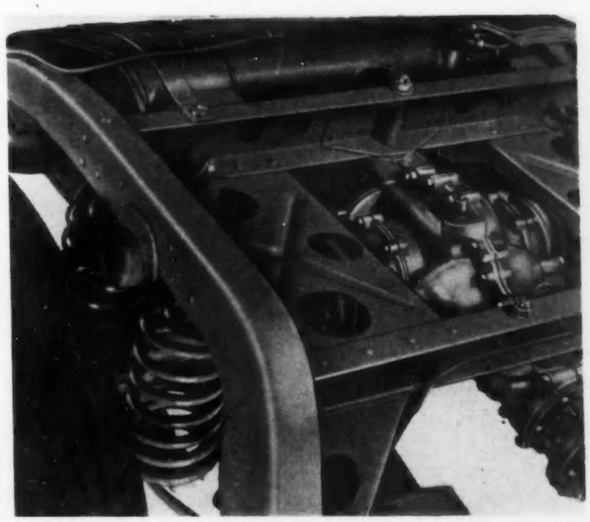
In England the Alvis company (D) has for some time employed an independent front suspension. A transverse leaf spring is bolted to a reinforced cross-member just behind the radiator and its ends are connected to the upper parts of the steering head brackets. Beneath, there are triangulated radius arms pivoted to the frame by needle-roller bearings. Piping from a centralized chassis lubrication system serves all bearings. André Telecontrol shock absorbers are used in which the friction surfaces are loaded by hydraulic pressure applied through rubber expanders. The driver can vary the pressure on front and rear pairs by means of screw-down controls and a double facia gage shows the loads employed.

Vauxhall adopted Dubonnet springing for the front end of the Light Six a year ago and this £200 car, which weighs 2400 lb. unladen, has been extremely successful.

The Singer company (C) has for some time marketed 9 hp. and 11 hp. cars with conventional springing or, to choice, with independent front springing at a small increase of price. The Gordon-Armstrong independent system is used in which each steering head is carried by two trailing arms and the load is taken by a coil spring in compression. A similar suspension is standardized on the 16 hp. Singer.

Early in 1935 the M.G. company produced its R-type racing chassis with all four wheels carried by transverse wishbones reacting upon torsion bars. This car has behaved very well in sporting events but has not been developed commercially. It remains the only British example of independent springing at both front and rear, and is also notable for a centralized frame structure. The M.G. company is numbered in the Morris group.

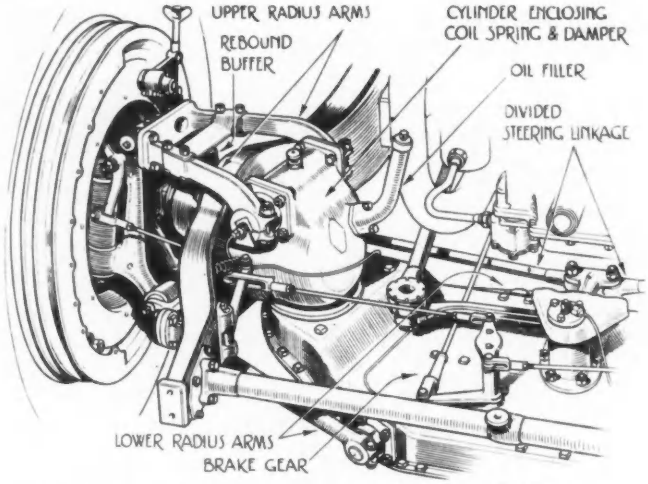
Great interest was aroused by announcements last October of the adoption of independent front springing by Rolls-Royce, Humber and Hillman. In the Rolls-Royce design, applied to a new 40-50 hp. Phantom III chassis which has a wheelbase of 142 in. and a 5 ft. track, each steering head is carried by paired radius arms at the top and bottom. The lower members are materially longer than those at the top so as to secure a constant track.



Independent rear suspension by coil springs as used in the five-liter Mercedes-Benz chassis. "Swing axles" enclose the half-shafts and are pivoted to the final drive casing carried by the frame.

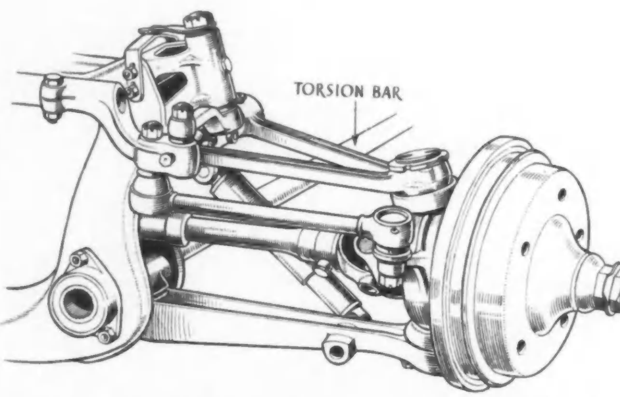
The upper arms are secured by clip bolts to the squared ends of a spindle journalled in a cylinder built into the frame. Within the cylinder a lever (carried by this spindle) reacts against a coil spring. A telescopic hydraulic shock absorber fits within the spring and the cylinder is filled with oil. Steering motions are conveyed to the wheels by half links from a centrally-mounted bell crank operated by the usual drag link. The weight of the car complete with saloon body is probably about 5000 lb.

As in previous Rolls-Royce practice the loading of the valves in the four shock absorbers is accomplished by a separate hydraulic circuit supplied from a gearbox-driven oil pump. Consequently, the damping increases in proportion to the road speed. Additionally, the driver has an overriding control (coupled to a bypass) by which he can vary the pressure created by the pump within certain limits. The same damping system is employed in the $3\frac{1}{2}$-liter Bentley and gives excellent results; the response is rapid and nicely proportioned.



The independent front suspension of the new Rolls-Royce Phantom III chassis, in which radius arms and an enclosed coil spring are employed. Note the divided steering gear and the pull rod operation of the front brakes.

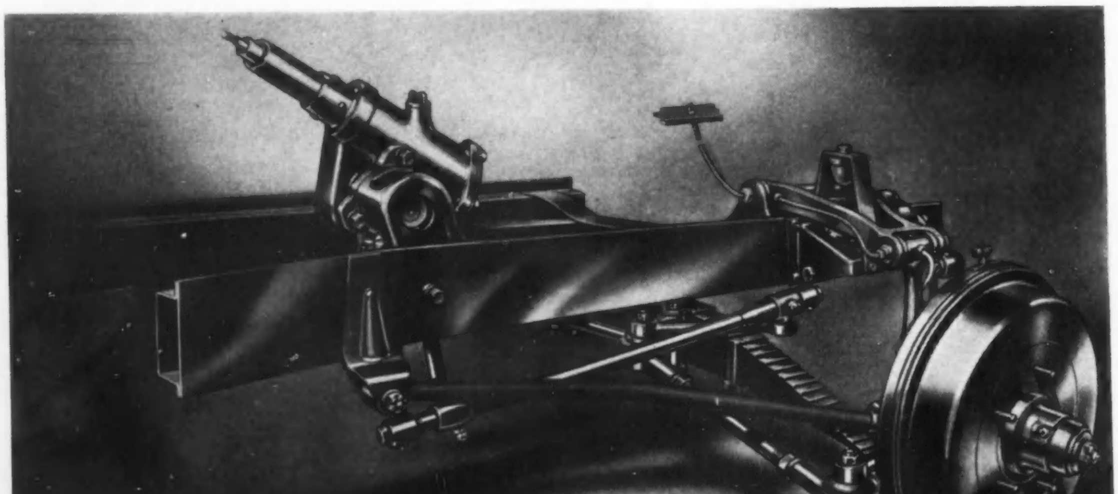
The six-cylinder Humber and Hillman chassis are built by associate companies (B) and in each case "Evenkeel Suspension" is a new feature. Rear springing is conventional but is supplemented (as in the Rolls-Royce) by a transverse torsional stabilizer mounted in bearings across the frame.



Torsion bar suspension of the front-drive Citroen with inclined hydraulic shock absorbers of the telescopic type. The lower radius arm is coupled to the torsion bar by dogs (not visible in this view).

At the front, the Humber-Hillman engineers use a transverse leaf spring bolted beneath a frame cross-member and coupled at the ends to the steering heads. The upper part of each head is located by a radius arm pivoted in brackets secured to the box-section side member of the frame. In addition, a longitudinal radius arm is taken rearwards to a pivot beneath the side member and provides extra stability against braking forces. Centralized lubrication systems serve all the bearings in the Rolls-Royce, Humber and Hillman layouts.

The many British car makers who continue to use conventional springing have considerably increased the flexibility of the front semi-elliptics. This has in several instances necessitated the location of the front axle by radius arms in order to retain stability and accurate steering at speed. In the Daimler light Twenty, for example, each front semi-elliptic is shackled at both ends and a pair of radius rods forms a longitudinal parallelogram at each side to provide positive axle location. In addition to improving stability



Evenkeel system of front suspension as adopted for six-cylinder Humber and Hillman models. A longitudinal link makes provision for brake reactions. Note the box-section frame.

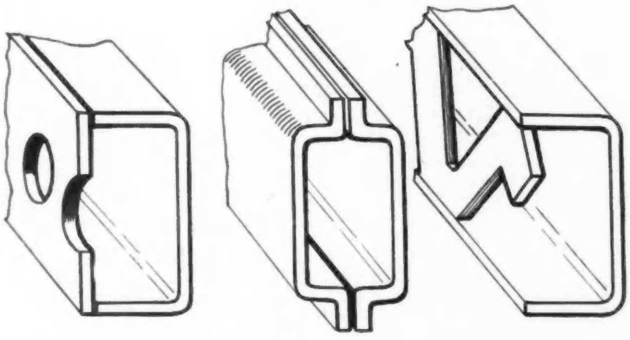
these rods permit powerful front braking to be used, although the static deflections of the front springs are 5.7 in. For the rear springs the figure is 7.25 in. This car has a wheelbase of 114 in. and an unladen weight of 3600 lb.

Armstrong Siddeley uses radius rods for the front axles of the 17 hp. and 30 hp. models. They claim that in addition to other advantages the torsional stiffness of these rods (which are coupled to axle and frame by substantial knuckles) provides a check upon rolling under fast cornering conditions.

Before concluding this section of my review, mention must be made of a new system of control for hydraulic shock absorbers which was announced at the London Show by Luvax. This concern is a division of Joseph Lucas Ltd. and supplies shock absorbers to a large number of British car makers. The new system will shortly be adopted for several well-known cars of medium price.

The bypass valves of the four shock absorbers are connected by piping to a small oscillating pump which is fitted to the spindle of one of the absorbers. The pump consists simply of a vane, with non-return valve, working in a small circular casing.

This loading system is inter-connected with a spill valve



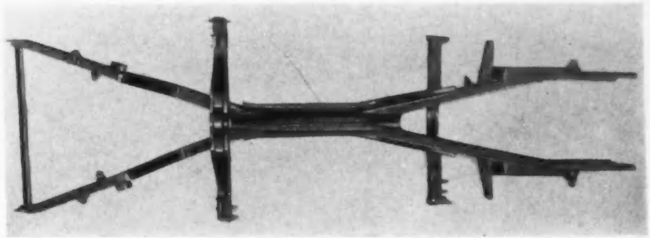
Cross sections of various frame side members, each built up by welding: (left to right) Morris, Renault and Daimler.

which provides a relief for the pressure generated. The rate of pumping depends upon the amplitude of axle movements and also upon the rate of which such movements occur. Consequently, the pressure, and thereby the damping effect, is fundamentally proportioned according to the rapidity and scope of springing movements. In addition to this automatic action the driver can vary the damping by a control which adjusts the orifice of the spill valve.

Frame Construction

The tendency to increase the rigidity of the frame in British cars dates back about eighteen months when Morris, Austin and many others adopted the so-called cruciform bracing amidships. This scheme was previously in use for many years in Delage chassis without attracting any imitators. A cruciform bracing by channels, bent inward toward one another and bridged at the center of the chassis, and extended along the side members for extra reinforcement, may result in an unduly heavy structure. Consequently, in the new cars the general plan is to use much stiffer side members of box section. These are built by spot welding two pressings or by welding a reinforcement strip to the flanges of a channel. Similar methods are used for cross-members or for cruciform bracing, when retained, and enable metal of a lighter gage to be used.

The more scientific distribution of the material in these



The unusual frame of the new $1\frac{1}{2}$-liter Fiat. The engine fits into the smaller fork at the front, and the larger fork, together with a cross-member, provides support for the rear semi-elliptics. Front suspension is on the Dubonnet principle.

structures, coupled with the employment of welding in place of rivets, has made possible a great improvement in the "rigidity/weight" ratio.

In the Morris Ten-four the side channels are reversed with flanges outwards and are boxed by welded strips pierced at intervals with circular holes. A steel tray amidships carries the accumulators, hand brake and front seats in addition to serving as a frame stiffener.

In the new Talbot-Ten the side members pass under the back axle; a plan favored for many small British cars. Behind the axle the side members are tied by a steel tray the front edge of which is turned up at right angles to provide an anchorage for transverse hydraulic shock absorbers. This tray also protects the under side of the petrol tank.

In a new frame made by Rubery Owen for the 10 hp. Hillman Minx (B), welded box sections are built from pressings for the side members and for four cross-members. In Lanchester and Daimler chassis (C) the side channels have a welded lattice reinforcement welded between the flanges. Renault (A) obtains a box section from symmetrical flanged U-section pressings welded together with flanges projecting vertically to form a central rib at the top and bottom.

The extremely ingenious Citroen Monocoque design will presumably be familiar to most S.A.E. members. The steel body is sufficiently rigid to dispense with any other framework and is extended in the form of two prongs (from the scuttle forward) between which is mounted the complete engine-front-drive unit.

Underslung frames, popular on small British cars, are exemplified by this Talbot-Ten. A steel tray protects the tank, reinforces the side members and is angled (at the front) to provide shock absorber mountings.

In the independently sprung British and French cars frames are mainly conventional in conception but are specially reinforced toward the front to give rigidity and a stable anchorage for radius arms, etc.

By far the most interesting development in Continental frame design is the backbone chassis. This was initiated by Tatra some years ago; a Czecho Slovak concern with remarkably able technical direction. The original Tatra design comprised a central tube, of large diameter, at the front end of which the engine-gearbox unit was mounted. The crankcase and tube constituted the "frame" and carried transverse leaf springs to form an independent suspension at the front and back. The body was carried by transverse bearers clipped to the tube.

From personal experience the writer can say that the steering, handling and stability of the 16 hp. four-cylinder Tatra are exceptional for a small car and are coupled with a marked degree of riding comfort. The wheelbase is 106 in. and the weight is claimed to be unusually low.

The tubular backbone principle was adopted by Mercedes-Benz for the rear-engined model introduced about 18 months ago and has also been employed by Skoda and by Austro-Daimler. On other German cars the backbone consists of a girder instead of a tube, examples being the Hansa and the Praga. A somewhat similar girder backbone is used in the unusual frame of the new 1½-liter Fiat. From this girder, amidships, frame members are splayed in a V toward front and rear. The forward pair carry the engine and Dubonnet springing. At the rear the V members, in conjunction with a cross-member, provide support for conventional semi-elliptic springs.

One other design of special interest is the B.M.W.; a German 2-liter sports car assembled and marketed in England by Frazer Nash. The side members of the frame are tubes of 4-in. diameter and are welded to cross-members of box section. The side tubes converge toward the front and are there connected by a structure which carries the transverse independent springing. The wheelbase is 96 in. and the saloon, complete, weighs only 1500 lb. Conventional springing by semi-elliptics is used at the rear.

Steering Gears

Adjustable steering columns constitute an interesting addition to the equipment of many British cars this year. The proprietary Bluemel-Douglas adjuster is employed, which allows the column to be telescoped over a range of several inches to vary the height of the wheel. This supplements the rake adjustment often provided in the bracket securing the column to the dash. A considerable rake is favored by European drivers.

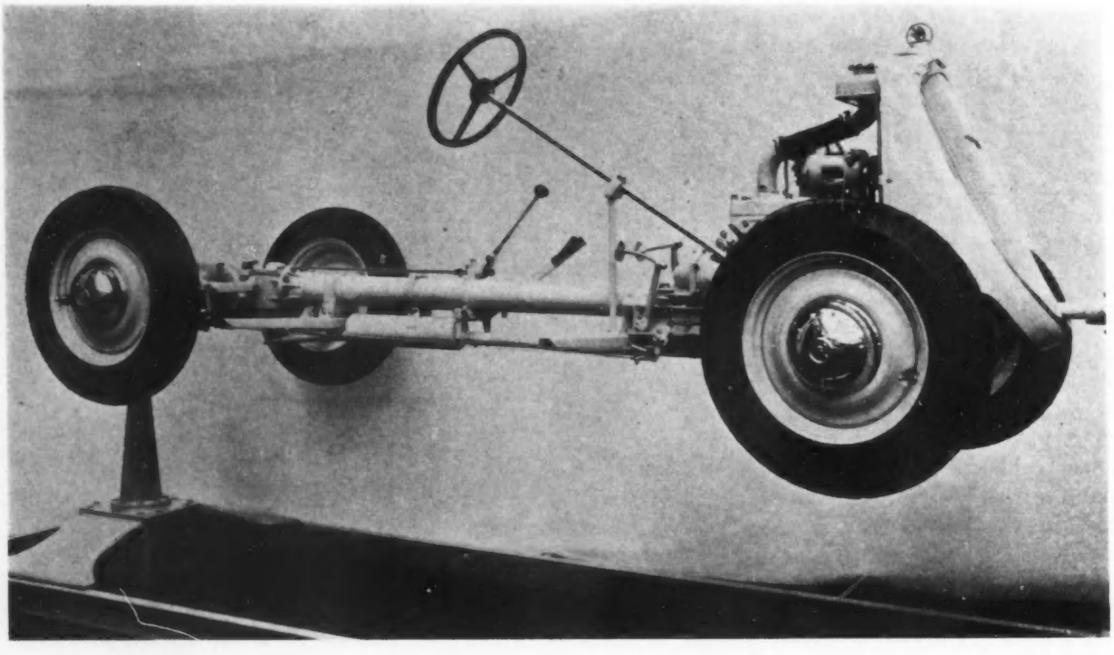
For cars with independent front springing the linkage connecting the steering arms is articulated at either one or two points by many makers and is coupled by a bell crank and drag link to a conventional steering mechanism. An alternative seen on the rear-engined Mercedes-Benz, the B.M.W. and the Tatra is a simple rack and pinion mechanism with the ends of the transverse rack ball-jointed to rods which run directly to the steering arms. With a sound system of independent springing it is surprising how steady and accurate this simple steering gear proves itself to be in practice.

Radius-arm control for the front axle, mentioned elsewhere in this review, also assists steady steering. Anti-kick shackles, never very popular in Europe, have almost passed out of use. By far the most popular front-end stabilizer on British cars is the Wilmot-Breedon spring bumper with loaded ends.

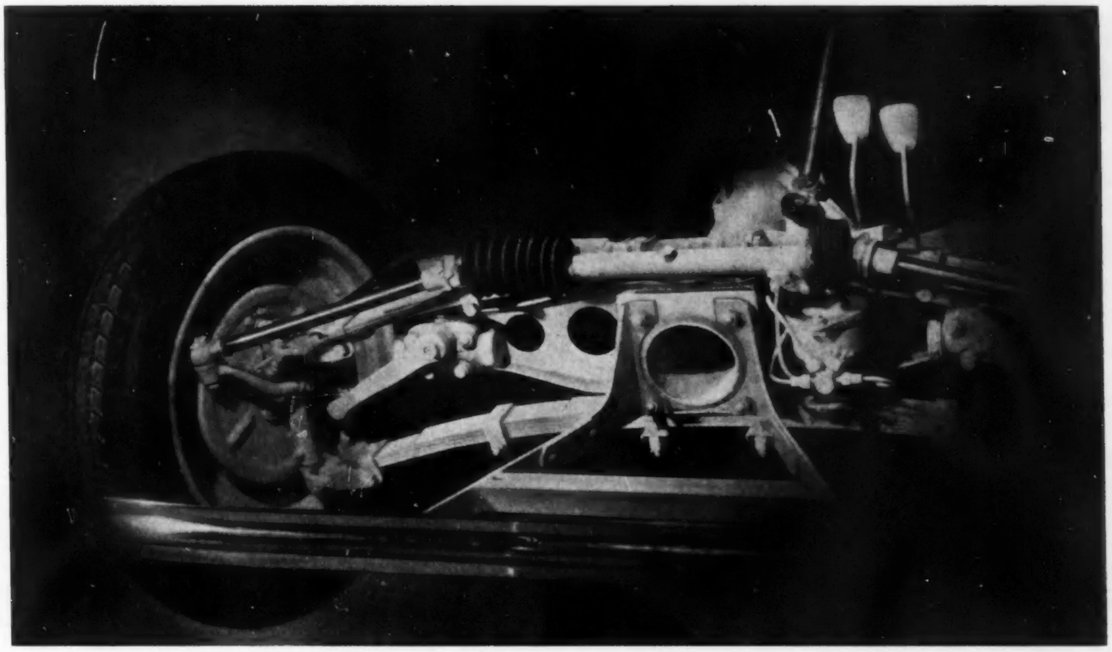
Steering linkages on cars with conventional front axles mainly employ a longitudinal drag link but there are important exceptions, such as Armstrong Siddeley (C) and Standard (B) who use a cross link. In the new Hillman Minx (B) the steering gearbox is mounted at the extreme front end of the frame with the drag link running rearwards. A similar scheme is used on many commercial vehicles with forward control, the driver sitting alongside the engine.

The Thompson self-adjusting track rod is quite widely used in which spring-loaded eccentric segments embrace ball studs fitted to the steering arms. Other makers use ball joints with spring-loaded plungers. A rubbered steering joint is used by Ford.

A popular steering mechanism used by Morris and others is the Bishop, in which a conical peg engages with a helical



The tubular backbone system, pioneered by Tatra, as exemplified by another central European product — the four-cylinder Skoda.



Transverse suspension and rack-and-pinion steering gear of the rear-engined Mercedes-Benz, also showing how the springing is mounted on the front end of the tubular backbone.

cam. This peg is carried by a rocker mounted on the drop arm spindle. End thrusts on the cam are taken by ball bearings and the thrust on the peg presses the flat back of the rocker against a cover plate. Shocks conveyed from the wheels squeeze oil from between these flat surfaces and are thereby cushioned. A duplicated Bishop mechanism has recently been brought out to operate a pair of drop arms and drag links for cars with independent front springing.

Another mechanism extensively used on British cars is the Burman-Douglas. A worm and nut are employed and the endwise motion of the nut is picked up by a peg fitted to a rocker arm. A third mechanism is the Marles Weller with helical cam and a novel kind of follower. Contact is made with the cam by the faces of hardened hemispheres which are carried in spherical recesses in the follower and have a self-aligning action.

Transmission Systems

After a quiescent period of about two years, transmission developments have once again become interesting. The outstanding feature is the widespread revival of epicyclic gearing. The commencement of this trend dates back to 1929, when Armstrong Siddeley (C) launched the Wilson gearbox in a range of six-cylinder cars of medium price. Designed by Maj. W. G. Wilson, an engineer who was responsible in part for the war-time tanks, this is a four-speed transmission which has proved very satisfactory in service. It is now employed by a number of leading British concerns, including the Daimler-Lanchester-B.S.A. group, Riley, Clement Talbot and Crossley, in addition to its retention by Armstrong Siddeley.

The success of this transmission is partly due to the self-adjusting and balanced type of contracting brake employed, and partly to the ingenious compounding of the gear trains in a way which reduces both tooth speeds and loads. The gearing runs very quietly and has a long life. Drawbacks in service are confined mainly to the need for fairly frequent drainage and replenishment, largely occasioned by the fact that the brakes work in the oil. The lubricant becomes loaded, in time, with fine particles of brake lining. An incidental feature is the facility with which gears can be preselected.

By moving the gear lever across a quadrant on the steering column, the driver sets a camshaft in the box. The actual change of gear does not take place until a pedal is depressed and released with the left foot. This causes a bus-bar to oscillate, against the loading of a powerful spring. The brake previously in use is thereby released and the preselected brake trigger is brought into action, allowing the spring to load the brake. A direct top-gear drive is provided by a small clutch within the box. When the gear lever is set at neutral, and the pedal is depressed, a catch holds the pedal down, leaving all brakes free.

The pioneers of this system used the bottom-gear brake bands as a clutch. This is still the case throughout the Armstrong Siddeley range, with the exception of the 30 hp. Siddeley Special, to which an independent clutch was added a few months ago. In the Riley (C) and Crossley (D) transmissions the Wilson box is employed in tandem with a Newton centrifugal clutch. Clement Talbot (D) uses the Wilson gearbox with a traffic clutch of their own manufacture. This is a centrifugal device which also embodies a reversed free-wheel. Under all normal conditions the drive is conveyed by friction surfaces, centrifugally loaded, but when over-running at very low speeds the free-wheel insures that the rear wheels shall always be able to drive the engine. This affords a smoother action in traffic, and has the advantage that the engine can be started by towing the car.

The Daimler group of companies employs the Wilson gearbox in conjunction with a fluid flywheel developed from the Föttinger hydraulic coupling. A Daimler combination patent on the use of this coupling in conjunction with an epicyclic gearbox has prevented other concerns from employing this system. Singer provides a "Fluidrive" transmission on certain models, but here a Sinclair hydraulic coupling is used with an ordinary gearbox, there being also a friction clutch to permit of gear changing.

The epicyclic type of gearbox is particularly well fitted for

use with an hydraulic coupling of this kind. The Daimler system has now been applied to some 25,000 private cars, and to a number of passenger-carrying commercial vehicles. The majority of drivers favor the ease of control which the fluid flywheel affords; it is probably the only kind of automatic clutching device which can be slipped for prolonged periods without suffering the slightest damage.

On the Continent, the development of the Cotal epicyclic gearbox had reached very important dimensions. At the Paris Salon it was fitted by the following makers: Chenard et Walcker, Delage, La Licorne, Peugeot, Salmson, Unic and Voisin. In this box electro-magnets are employed in place of the more usual spring-loaded friction brakes, and these work in oil with suitable protection for the electrical wiring. The oil film undoubtedly helps to cushion the pick-up of the electro-magnetic surfaces. The driver simply moves a lever which operates a series of switches, and the gears are changed as soon as the circuits are completed. This box is being made in four-speed form for private car manufacturers and was also shown at the Salon as a six-speed transmission in various Latil commercial vehicles. It has been employed in rail cars in conjunction with Sinclair hydraulic couplings.

When tested by the writer in a 20 hp. car it was found advisable, though not strictly necessary, to ease the clutch before changing gear. Current consumption was 2 amp. on a 12-volt circuit. A separate control lever enabled the driver to select an independent neutral, a direct coupling for forward travel or a reverse through planetary gears.

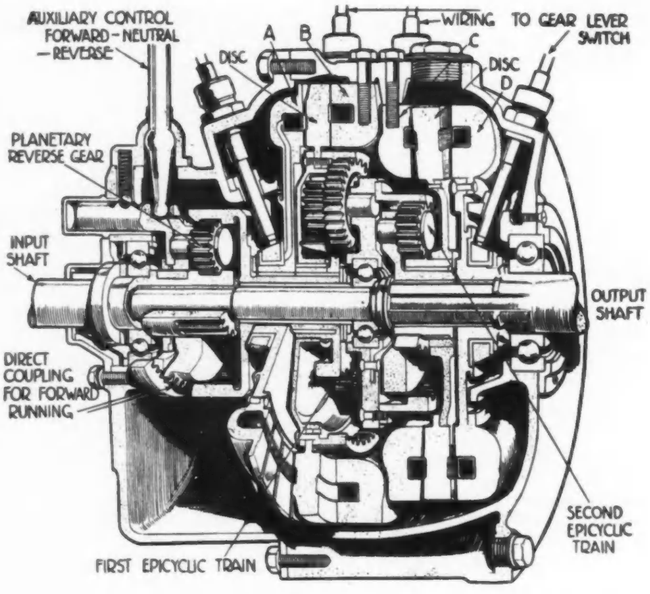
Referring to the sectioned drawing of the four-speed Cotal box, there are two rotating magnets (A and D), fed by brushes, and two fixed magnets (B and C). Between each pair are mounted iron discs with surfaces broken by radial grooves. The magnets are energized in the following pairs: first gear, B and C; second gear, B and D; third gear, A and C; top (direct), A and D.

Peugeot offers the Cotal gearbox with Fleischel automatic control as an optional extra, costing about £30. The action of the Fleischel mechanism depends upon engine load and speed in response to which it operates the switches controlling the Cotal gears. The characteristics of this mechanism can be varied by the driver, who has a control marked "town, country, mountains," the position of which decides the precise speed and torque at which the gears shall be changed.

Further evidence of the success of the epicyclic principle is found in the de Normanville gearbox, which was adopted for the larger six-cylinder Humber models last May and is an optional extra costing £30. There is no attempt to use the brakes in the box as clutches, there being a separate clutch of normal design between the engine and gearbox. The controls are inter-connected so that the driver cannot move the gear lever (mounted on the steering column) until the clutch pedal is depressed. The movement of the lever sets a series of valves, and so permits hydraulic pressure to be exerted upon the appropriate brake. This pressure is created by an oil pump inter-connected with a spring-loaded hydraulic "accumulator."

Another new epicyclic transmission has just been introduced by Crossley for an oil-engined 'bus chassis. It provides a direct top gear and three indirect forward gears. Automatic selection of the gears is effected by a series of plate clutches, the action of which depends upon the torque-load and speed on each planetary gear cluster. Pivoted rotating weights provide the end load on each clutch.

When a predetermined torque is exceeded, the corresponding planet carrier tends to reverse and is prevented from doing



The Cotal electro-magnetic gearbox in section. Epicyclic trains and four magnets provide three indirect ratios and a direct drive. The auxiliary gear on the left affords either a direct coupling or a reverse and is controlled by a separate hand lever. The electro-magnets are energized through a switch gear controlled by a lever on the steering column.

so by a ratchet device. The planets then give a reduction of ratio until the load falls, whereupon the carrier again rotates, and the plate clutch re-engages to permit that particular gear cluster to rotate en masse.

For the majority of cars produced in quantities in Britain, France, Germany and Italy, a synchromesh type of transmission predominates; it is also used in various forms by leading manufacturers of specialized cars such as Rolls-Royce, Alvis and Hotchkiss. Austin (A) and Standard (B) adhere to the four-speed box and use synchronized engagement for second, third and top; Vauxhall (B) provides four speeds with synchromesh for third and top only. A similar box is used by Opel (A) in Germany.

Until recently the Ford (A) was the only British-built car of low price with a three-speed box. Now, however, the Morris (A) Series II models and the new low-priced Singer Bantam (C) have three-speed transmissions with synchromesh for the top and middle gears. Similar transmissions are used by Citroen (B) and Renault (A) in France. In all countries the cheaper cars employ a simple synchromesh mechanism, usually of the Warner type, while the more costly productions use an interrupter type of mechanism which provides a positive check until speeds are synchronized.

Synchromesh for every forward gear of a four-speed box has been used for some time by Alvis, and has been more recently adopted for certain Humber, Hillman and Talbot models produced in fair quantities.

In European cars the chief protagonists of the over-speed principle are the Germans. It is employed, for example, by Mercedes-Benz and Maybach. The overdrive is provided by helical gears, in constant mesh, with an easy dog engagement. The dogs are spring loaded by moving a lever and jump into engagement when the accelerator is momentarily released.

The Maybach company has also developed an interesting four-speed pre-selective gearbox using eight helical gears in

constant mesh. These gears, arranged on two parallel axes, are ingeniously employed in groups of four to provide three alternative reductions between the clutch shaft and tail shaft. The dog clutches which select the various combinations, and also the direct drive, are shifted by pistons working in cylinders exhausted by engine suction. Levers above the steering wheel enable the driver to select the gears and are connected to the suction valves. As in the Maybach overdrive, the dogs are of special shape and will not drop into engagement until the speeds of the mating parts are approximately synchronized.

The free-wheel was used by Chenard et Walcker in France as far back as 1924 and appeared in England in 1925 without attracting much serious attention. Following the vogue of free-wheeling in America a few years later, the device reappeared upon a number of British cars. It has now been largely abandoned with the important exception of Rover (C), who employs the free-wheel for medium-priced models and makes it a strong sales feature. These cars sell to a discriminating public.

The sole example of an automatic transmission on British cars is the Austin-Hayes Self-selector which is an optional extra costing £40, available only on the 16 hp. and 18 hp. Austin chassis. Formerly, it was controlled by two levers, one of which determined the load on the hydraulic relief valve, which sets the balance between torque and gear ratio, while the other operated a sleeve valve which limited the maximum revolution speed reached by the engine. The latter control has now been abandoned in the interest of simplicity.

The drive, through six friction discs placed between toroid races, remains much as before. Torque loading tends to make the discs run to a lower-geared position in the races while any increase of engine speed, by raising the hydraulic pressure, has the effect of moving the discs toward a higher gear position. A valuable feature is the "step-up" ratio of 1 to 1.7 available when cruising at part throttle or when over-running. Separate gears provide a reverse and are controlled by a lever which is also used to give a neutral. The box is filled with a special lubricant named "Drivex"; drainage is recommended at 5000 mile intervals. End load on the discs amounts to 1400 lb. and is applied by three spring washers.

With the exception of the Newton Centrifugal clutch and the hydraulic couplings already mentioned automatic clutch mechanisms are rare. Only a few makers employ the Bendix suction-operated device. A new system dependent upon hydraulic pressure generated in an engine-driven oil pump has been under development by Gillett Auto Units Ltd. for some time and is now making headway. It has not as yet been fitted by any car manufacturer. In Germany another form of hydraulic clutch withdrawal is now employed in the Hanomag light car. Foot-operated clutches are almost all of the conventional single-plate type.

There are few exceptions to the use of a unit-constructed gearbox and open propeller shaft, the latter with Hardy Spicer needle-bearing universal joints. Torque tubes are, however, employed by several notable concerns such as Renault, Talbot and Armstrong Siddeley. Bugatti uses a torque arm alongside an open propeller shaft. Tatra drives rear wheels on "swing-axles," without using universals, by using two crown wheels which roll on their respective pinions as the axles move on their trunnions.

In low-priced chassis the rear axle casing is often made from two pressings welded together along vertical seams. An alternative considerably used in England is the patented Scott axle case made by Rubery Owen. This is produced from a solid drawn steel tube slit and expanded at the center and swaged down toward the ends. Brackets for the spring seats are welded in position. The B.M.W. seems to provide the sole example of a non-vertical banjo, this part of the axle being inclined at 45 deg. Austin uses a very robust axle case formed from two steel castings bolted together at a central

How the complete engine-transmission unit of the front-drive Citroen can be wheeled away from the steel body structure. Note the mounting of the battery on the scuttle.

vertical joint. Alvis, in a high-grade chassis, casts the casing in aluminum and uses internal alloy-steel tubes as a reinforcement. At the outer ends the tubes carry hub bearings on the fully floating principle. The Austin design is three-quarter floating; in most inexpensive cars the semi-floating axle is used.

German designs of "swing axle" adapted for independent rear springing are described under the heading of Suspension Systems.

Spiral-bevel final drives are general with the exception of Daimler and Lanchester in England and certain German front-drive cars, such as the Audi. A worm drive is also used in the rear-engined Mercedes-Benz.

Front-drive cars have a considerable vogue on the Continent but are represented in England by one model only—a sports chassis built by B.S.A. Continental examples include Citroen, Chenard et Walcker, Rosengart, Audi, Adler and D.K.W. At the moment there is no indication that other manufacturers will become adherents to this system. Longer wheelbases are usually found in front-drive chassis, employed to lessen the transfer of weight from front to rear occasioned by drive reaction. Another point is the general practice of placing the final drive mechanism between the engine and its gearbox, so economizing chassis space.

Braking Systems

For some years brake improvements have centered upon reducing the friction losses between pedal and shoes. Manufacturers of brake linings have also been active in developing materials with longer life and a greater resistance to high temperatures.

Two braking systems familiar to American engineers—Lockheed Hydraulic and Bendix Duo-servo—are made by independent companies in British factories and are both widely used. Morris (A) is the principal exponent of Lockheed and the Bendix system is employed by Standard (B), Humber-Hillman (B) and others. The Austin (A), Ford (A) and Vauxhall (B) factories make their own brake equipment. As noted later, Austin has recently adopted a proprietary brake for certain chassis.

Citroen (B) adopted Lockheed brakes about a year ago and this system and the Bendix brake are both widely used on the Continent. Their brief treatment in this review is a measure of their familiarity rather than their importance.

A young but very healthy competitor in England is the Girling system which the writer first tested and described in *The Motor* five years ago. It took the inventor two years to obtain manufacturing facilities, following which his system was adopted by the Rover company (C). It is made by New Hudson Ltd. and is now used for the 16 hp. and 18 hp. Austin chassis (the first time that proprietary brakes have been employed by this company) and by Daimler, Lanchester, Lagonda and others.

From a compensating lever adjacent to the pedal pull-rods extend directly to levers secured to short vertical spindles carried on the front and rear axles. Each spindle also carries double-arm levers from which pull-rods are taken to brake shoe expanders. Each expander consists of a cone operating rollers and plungers which apply outward forces to the shoes. At a diametrically opposite point the back plate carries a screwed cone expander which provides adjustment for wear between the shoe tips.

But for the short levers on extremely short spindles the whole system is in tension and is therefore unusually free from spring or "give". Furthermore, the mechanical advantage is mainly concentrated at the shoe tips so that only a light load is carried by the pull-rods. The hand lever is interconnected through a sliding joint. In practice this brake provides a low pedal pressure, retardation proportional to applied effort and a capacity for "staying put" with very little attention.

In British private cars experiments are being made with proportionate braking which the Humber company has been first in adopting. The principle is one which was successfully applied to motorcycles by Rudge Whitworth some years ago. It consists of employing pre-compressed springs in the operating gear which restrict the total load that can be applied to the rear brakes. Beyond this, any increase of pedal pressure is mainly employed to build up braking on the front wheels only which is logical in view of the big transfer of weight from rear to front which occurs when a car is forcibly retarded.

In the writer's opinion this proportionate principle has great possibilities and will become more widely used. It has little effect upon relative rates of lining wear, front and back, because it is effective only as emergency stopping conditions are approached. The improvement in safety when braking at speed or on slippery roads is most marked.

For brake drums steel pressings are widely used. Iron castings are employed on some medium-priced cars and a few Continental makers of high-priced chassis use aluminum alloy drums, with circumferential fins, and iron or steel liners. Nitrogen-hardened steel liners have been fitted by the Laystall company to quite a large number of brake drums on commercial vehicles. They appear conducive to smooth action and are also kind to the linings.

Bodywork, Style and Appearance

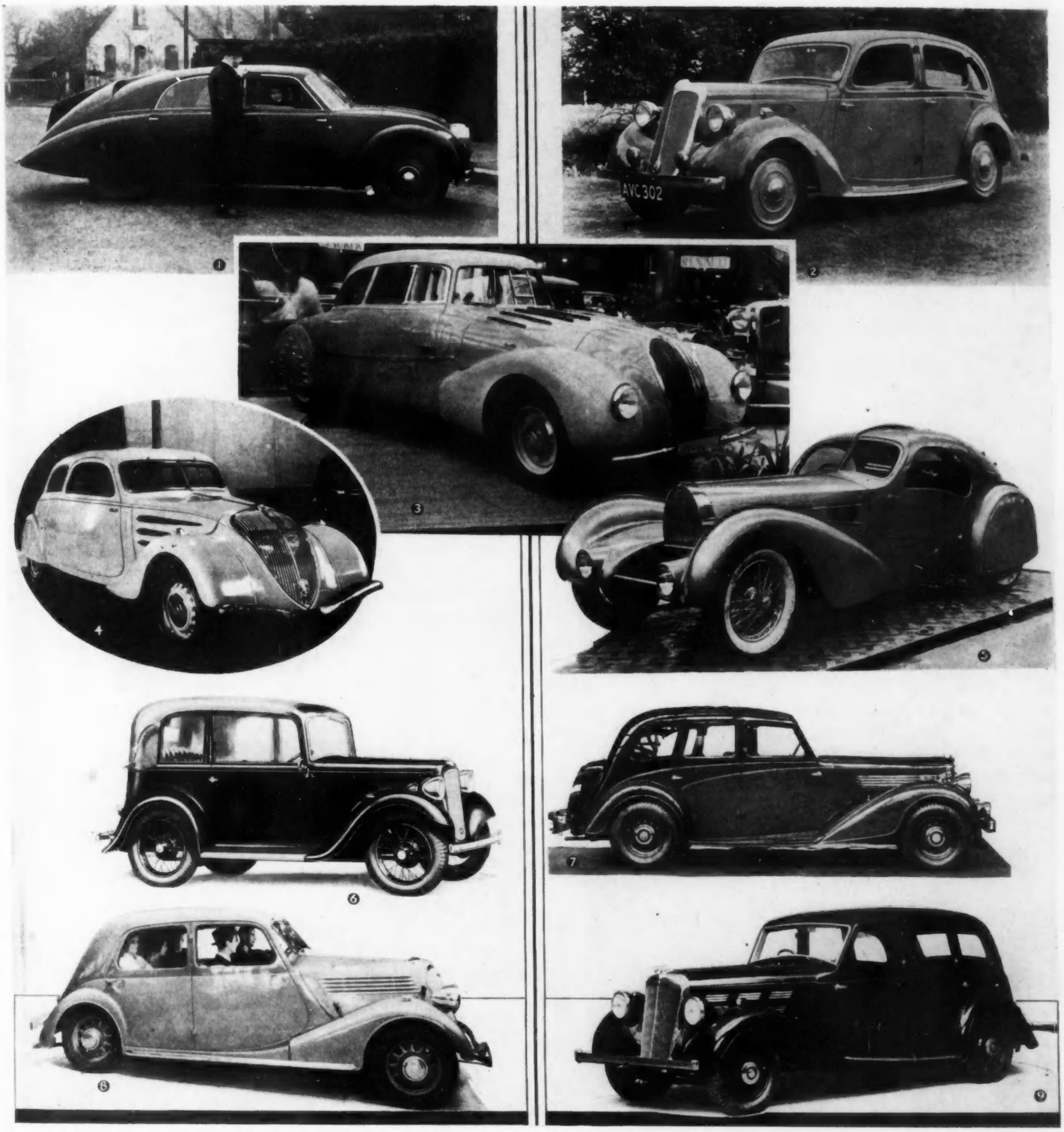
The forward shift of radiator, engine and body has materially altered the appearance of most European cars during the past year. American influence is clearly seen in the principal mass-produced makes in which a false radiator front has been adopted, merging into the wings and raked backwards from a point over the front dumbirons.

While practical gains in seating comfort, door locations, etc., have resulted from moving the body forward, the change in frontal appearance is not so favorably regarded by motoring enthusiasts. The general public accepts the "snow-plough" front but to the cognoscente a good car is still associated with an upright radiator (set well back) and with restrained lines. Consequently firms such as Rolls-Royce, Alvis, Talbot, Mercedes-Benz, Horch, Hispano-Suiza and others, to whom prestige is all-important, are careful to avoid any marked change in frontal appearance. Even so, their radiators are now a little further forward, and their bonnets have been lengthened rearwards over the scuttle.

Almost alone among the big producers Austin (A) retains an almost vertical radiator and builds bodies in which upright lines predominate. Presumably this is found helpful in appealing to the conservative (and numerous) section of the British public which appreciates consistency more than initiative. The Austin policy also tends to maintain used-car prices.

Morris (A) has attained great success in quite a different way by introducing during the season the "series II" types of four-cylinder and six-cylinder cars. These have in com-

Usual and Unusual Examples of British and Continental Body Design



1.—The Tatra saloon with air-cooled V-8 engine at the back, which is built in Czechoslovakia.

2.—The new 12 hp. Standard Flying Saloon. In this streamlined model the spare wheel and luggage are enclosed in the tail.

3.—German streamlining as exemplified by a most unusual saloon body built by Maybach on a powerful six-cylinder $3\frac{1}{2}$-liter chassis.

4.—The Peugeot Model 402 which was first shown at the Paris Salon last October. Headlamps are enclosed behind the radiator grille.

5.—Streamlined coupe on the straight-eight Bugatti sports chassis. This body, built largely of Elektron, weighs only $2\frac{1}{2}$ cwt.

6.—A cabriolet on the Austin Seven chassis, listed at £128. This maker adheres to conservative styles.

7.—21 hp. Wolseley Super Six, recently introduced in England, in which double panel moldings permit a three-tone color scheme.

8.—A typical example of the Renault range is this 17.9 hp. Big Four saloon with wide coachwork, side bumper bars and no running boards.

9.—The Morris Series II 18 hp. saloon which is selling in considerable numbers. It is listed at £250 in fixed-head form.

mon a severely raked windscreen, slanting rear panels and graceful moldings along the sides; in general appearance they are quite different from any previous Morris production. All four doors are swung from the central pillars, those at the front following the slant of the screen so that their forward edges break into the scuttle and provide extra footroom when open.

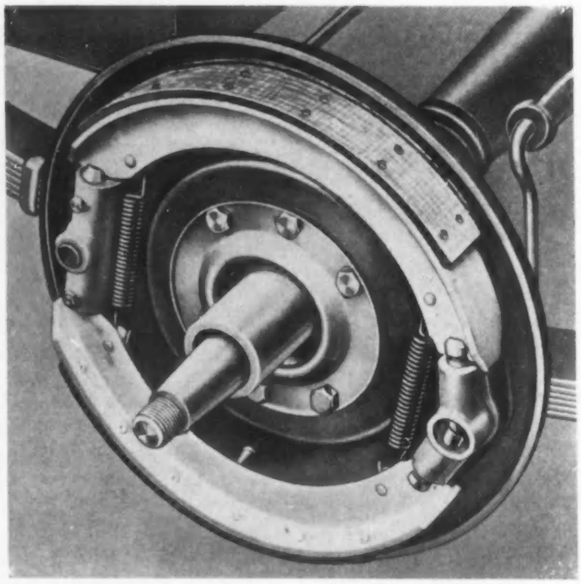
All-steel bodies are employed by Citroen and Renault in France, and by Ford, Standard, Hillman and Singer in England. Even Riley, who formerly concentrated upon hand-built composite coachwork, came to the London Show with an all-steel saloon on the 9 hp. chassis.

Against this, Austin, Morris and Vauxhall still employ a small amount of timber as filling and reinforcement for steel paneling and pillars. In each case production of certain models is on a scale far in excess of the minimum required to justify an all-steel job. Presumably design preferences account for the retention of a certain amount of wood.

Miscellaneous Equipment

Under this heading the writer proposes to confine his remarks to certain items of equipment which do not appear as yet to be widely used in America. Chief among these is the electric semaphore signal the use of which is practically universal throughout Europe. So much has it become a standard fitting (enforced by law in many countries) that car makers build it into the body where it fits flush when not in use. The favorite mounting is in central door pillars but the scuttle and rear quarters are also used. In a recent British regulation the fitting of a signal more than 4 ft. behind the windscreen is made illegal.

Simple time switches are popular on the Continent which restore the switch and signal to their inoperative positions after a fixed interval. In England the Lucas self-cancelling switch is widely used. This is mounted above the steering wheel and is connected with trip levers which throw it back to the off position when the steering is centered after negotiating a corner. Without some device of this kind drivers are apt to leave signals extended.



The Girling brake as fitted to the 16 hp., 18 hp. and 20 hp. Austin chassis. The shoes are expanded by a pull rod operating a wedge, rollers and plungers.

Permanently fitted jacks are now very popular on British cars; a development encouraged by the vogue of low-built coachwork with extended tails.

Facia equipment has tended in the direction of grouping the instruments which, for British motorists, must include a clock. Accessory houses are selling warning devices, audible and visible, to tell the driver when he is exceeding the new British legal limit of 30 m.p.h. in built-up areas. They also market change-over switches which enable the horn button to operate an auxiliary lamp signal for use at crossings when horn sounding is prohibited after 11.30 p. m. Neither of these devices has as yet found a place in standard equipment.

Constant-voltage regulation has superseded third-brush control in the electrical equipment of all but low-priced cars, ventilated dynamos are general, British makers remain faithful to 12 volts, Continental builders are divided between 6 and 12 volts, and single-pole wiring is almost universal.

Most British cars use the Lucas solenoid-controlled dipping reflector in the near side headlamp with the pivot axis tilted so that the dipped beam also swings toward the edge of the road. When the dip switch is operated the off side headlamp is cut out. On the Continent two-bulb headlamps, double-filament bulbs and auxiliary pass lamps with flat-topped beams are all in use. In France, stricter legislation has enforced the adoption of clear, internally-lit rear number plates during the past year.

Radio is making headway in Europe but is still rather costly. Provision is made for its ready installation by many makers but only a few market radio-equipped models at inclusive prices. During the past year most of the Paris taxicabs have had radio installed.

After enjoying a great vogue for several years the wire wheel is beginning to give place to the pressed spoke wheel both in England and on the Continent. Pressed wheels are being made in England by Dunlop, Rubery Owen, Sankey and Kelsey Hayes.

There are no signs of misplaced economy in tire equipment; on the contrary, tires sections tend to increase—16-in. and 17-in. rims are popular but diameters of 18-in. and 19-in. are still used on the more costly cars. During the year Dunlop brought out a new "90" series of covers with treads specially designed for quieter running. These are factory equipment on the majority of British cars and have also a considerable volume of sales on the Continent where the Dunlop company has established subsidiary plants.

Easy maintenance is important on European cars because many owners of low-priced models attend personally to lubrication and simple adjustments. Silentbloc rubber bushes are widely used for spring eyes and shackles. In medium-priced vehicles one-shot lubrication systems have increased in popularity.

Conclusion

The writer would like to record his appreciation of the honor accorded to him in being invited to write this review of European automobile trends. The selection of material for a condensed summary of this big subject was by no means easy. My aim has been to present to my American confréres a balanced account of the work of designers over here, with special reference to trends which seem to me to be destined to endure.

My thanks are due to Temple Press Ltd., publishers of *The Motor*, for full permission to use information acquired in their service and illustrations made by their staff.

N.A.C.A. Study of Radial Air-Cooled Engine Cowling and Cooling

By Donald H. Wood and Carlton Kemper
National Advisory Committee for Aeronautics

THE development of an N. A. C. A. cowling giving a low drag and satisfactory engine cooling for a particular airplane and engine installation requires the construction and flight testing of numerous experimental cowlings.

An investigation has been undertaken by the National Advisory Committee for Aeronautics to determine a rational basis for the design of the N. A. C. A. cowling.

The effect of front and of rear openings and of inner and outer lines of the cowling on the quantity of air flowing through the cowling, the pressure drop, and the drag have been determined from tests of models in a wind tunnel.

The quantity of air and the pressure drop required for satisfactory cooling of a given design of air-cooled cylinder have been determined from tests of a single-cylinder engine.

The results obtained from the tests of the models and the single-cylinder engine are being checked in a large wind-tunnel using a 550-hp. radial-engine fitted with a propeller.

The effect of air speed, air density, and cooling-air temperature on the temperature of air-cooled cylinders has also been investigated.

The multi-cylinder-engine tests have been found to check the model tests and to give the effect of the propeller on the quantity of air flowing through the cowling.

The method proposed for designing the N. A. C. A. cowling is outlined in the report.

THE majority of high-speed airplanes are powered with radial air-cooled engines and use N.A.C.A. cowling to obtain a low engine-drag. With increase in the specific power-output of air-cooled engines and the use of controllable and constant-speed propellers permitting full power to be developed in climb, the difficulties of obtaining a cowling giving a low drag and satisfactory engine cooling have increased.

The early studies of cowlings were mainly directed toward proving the merit of the cowling as a means of reducing the drag due to the engine, and little attention was paid to obtaining satisfactory engine cooling. No attempt was made to determine the quantity of cooling air flowing through the cowling. The information available[1] concerning the principal variables affecting the performance of the cowling has been obtained by experimental tests of cowlings on several airplanes. The investigation by Beisel[2] gives information on the comparative effects of the variables affecting the performance of the cowling. No attempt was made in that investigation to obtain data which could be used to predict changes in performance.

The most recent N.A.C.A. investigation is being conducted with the object of obtaining sufficient data to place the design of the cowling on a rational basis. Tests on a four-ninths scale model of an engine having an overall diameter of 45 in. have been conducted in a wind tunnel to determine the effect of a wide range of front and rear openings and shape of inner and outer lines of the cowling on the quantity of air flowing through the cowling, the pressure drop, and the drag. Single-cylinder-engine tests are being made to determine the pressure drop and minimum quantity of air required to cool satisfactorily a given design of engine cylinder for a wide range of power outputs and specific fuel-consumptions. The results of the model and the single-cylinder-engine tests are being checked on a 550-hp. radial air-cooled engine in the

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 17, 1935.]

[1] See N.A.C.A. 1929 Reports Nos. 313 and 314; "Drag and Cooling with Various Forms of Cowling for a 'Whirlwind' Radial Air-Cooled Engine," by Fred E. Weick. See also N.A.C.A. 1932 Report No. 414; "The Effect on Airplane Performance of the Factors That Must Be Considered in Applying Low-Drag Cowling to Radial Engines," by W. H. McAvoy, O. W. Schey and A. W. Young. See also S.A.E. JOURNAL, February, 1932, p. 84; "Engine Cooling Problems with Venturi Cowling," by R. R. Higginbotham.

[2] See S.A.E. JOURNAL, May, 1934, p. 147; "Cowling and Cooling of Radial Air-Cooled Aircraft-Engines," by Rex B. Beisel, A. Lewis MacClain and F. M. Thomas.

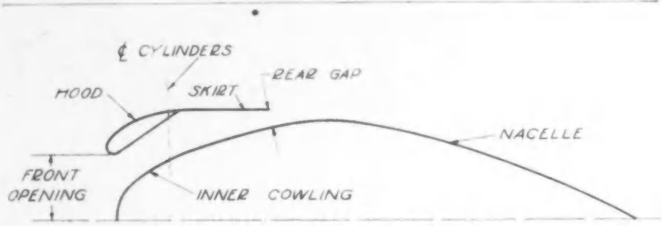


Fig. 1—General Features of the N.A.C.A. Cowling

In model tests, screens are placed at the position of center line of cylinders to simulate resistance of cylinders and baffles.

propeller-research tunnel. The results of these investigations should reduce to a great extent the number of experimental cowlings that must be built and flight tested to determine a suitable design of N.A.C.A. cowling for a given airplane.

Model Cowlings

The general features of the N.A.C.A. cowling are illustrated in Fig. 1. The engine is surrounded by a ring, or hood, extending forward of the engine cylinders nearly to the propeller disc and terminating in a skirt behind the cylinders. An inner cowling is fitted over the forward part of the crankcase and extends back above the mounting ring, running smoothly into the lines of the nacelle or fuselage. In some installations, the inner cowl may start at the mounting ring. The air for cooling the engine enters the hood at the front opening and passes through the cowling and around the cylinders, leaving between the skirt and inner cowling at the rear gap.

The Cowling Problem.—The character of the flow, that is, the pressures and velocities at various points, consequently, the drag and cooling, is determined by the shape and location of all the above-mentioned elements. Changes in the size of the opening and in the shape produce changes in the air velocities and pressures. The object of the cowling tests is to determine the variations in the quantities that are important in design; namely, air volume through the cowling, head loss, and drag. The number of conceivable shapes is, of course, very large, but the number of practical ones can be reduced to a reasonable number from considerations of form based on previous experience and common sense. Starting with a shape consistent with established ideas of streamlining, the necessary variations introduced will be only slight departures from it.

The cowling and cooling problem resolves itself into the determination of the required entrance and exit areas to insure a sufficient flow of air for cooling with a cowling shape giving the least drag. The testing of a series of related shapes will yield comparable information and, although the absolute lowest drag may not be obtained, the relative values will at least indicate the direction in which to proceed for further drag reduction and, by comparison, the probable value that may be obtained.

A comprehensive series of tests could be made using an actual engine installation, but the time and expense involved would be out of all proportion to the results obtained. Furthermore, the operating engine and propeller introduce complications that are more easily eliminated at first by tests of models.

Cowling Models.—In order to make the models as large as possible to reduce scale effect and to make possible the ready installation of measuring apparatus, the model used in the N.A.C.A. investigation was made four-ninths the size required for a 45-in.-diameter radial-engine. The model scheme illustrated in Fig. 2 involves the novel feature of having the cowling under test represent one-ninth of the complete cross-section of the engine. This feature, suggested by Fred E. Weick of the laboratory staff, involves the mounting of the model near the apex of two plates, forming a V. The plates serve to confine the flow to the space between them and the installation of a horizontal inclined plate at the top—not shown—allows the pressure drop, which occurs in all wind tunnels, to be eliminated from the cowling under test. Another important advantage is the use of cowling shapes of single curvature, as the curvature in the circumferential sense is small in one-ninth of the total circumference. This feature saves time and expense in construction and allows changes to be made very quickly.

The engine cylinders and baffles constitute essentially a resistance to flow and, to secure wide variation in the resistance, the cylinder and baffle is conveniently replaced by a series of square rods of various sizes, forming screens. Orifices are located on the side plates as shown in Fig. 2, just in front of and behind the screen. These orifices are connected to a U-tube manometer. The pressure readings thus indicated are checked with a survey over the screen and, by suitable integration, the pressure drop across the screen is determined. Another series of orifices located on the plates at the front edge of the cowling hood is likewise calibrated to determine the volume of air flowing through the cowling.

The side plates are divided as indicated in Fig. 2 at 12 in. from the apex and the upper portions are suspended free, only the lower portion and attached cowling being connected to the balance. The drag of the plates, which is considerable, is thus eliminated from the drag readings.

Model Tests.—The tests of the various models of this type

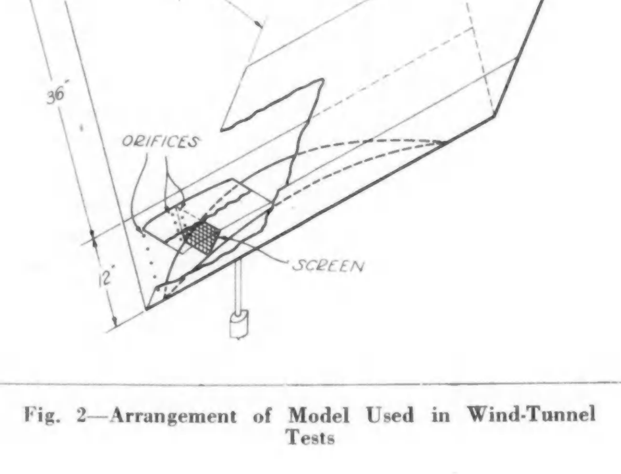


Fig. 2—Arrangement of Model Used in Wind-Tunnel Tests

were made in the 7 by 10-ft. wind-tunnel at an airspeed of 80 m.p.h. The variety of cowling shapes investigated is shown in Fig. 3. The size and shape of the hood and skirt as well as the inner cowling were changed as indicated, resulting in a wide variation in front opening and rear gap. In most cases five different screens were used, representing a wide range of resistances. In each case readings were taken from which the pressure drop, volume, and drag could be computed. Since each screen represents a definite resistance, the volume flowing for a given head-loss may be represented on a single diagram for all cowlings. The variation for the models at the test speed is indicated in Fig. 4. It is to be noted that the screens used varied from 56 per cent to 5 per cent of the free area. These screens covered the range from beyond the most open engine to below that of a closely baffled one.

Corresponding to each head-loss and volume is a drag value for each cowling. It is accordingly very difficult to get any useful information from the great mass of data without changing its form. It will be noted from Fig. 3 that, for each of several front openings and shapes, there were several changes in the rear opening. It is convenient to place all the data for one front opening and shape on a single diagram.

The advantages of non-dimensional coefficients are also recognized. Accordingly, a series of diagrams has been prepared by calculations and cross-plotting from the model-test data giving the results for a given front opening and shape with various rear openings. Fig. 5 is typical of these diagrams. The volume of air reduced to coefficient form is plotted against the head-loss, also in coefficient form, for various values of the rear opening or gap coefficient as shown in solid lines. The dotted lines represent the corresponding drag coefficients.

Cowling Design.—This type of diagram is considered very useful in cowling design. Although the values given are from the model tests and probably will require corrections, these corrections will be determined in other parts of the program to be discussed later. The reader, therefore, is cautioned against using this particular chart for design purposes. The use of the diagram may be described as follows:

Assume that it has been found, from tests of a single-cylinder engine, that a given quantity of air is required to cool the engine of given power at a certain speed and that the pressure drop through the cylinders and baffles is determined. The volume and head-loss coefficients can then be calculated from the formulas given in Fig. 5. Entering the diagram with the calculated volume and head-loss coefficients, the rear-gap and drag coefficients are determined and from them the corresponding required rear-gap and the resulting drag. Other values are similarly determined from other charts.

The arrangement giving the least drag will be the one to use for the particular power and speed. If another speed is also critical, a new set of values can be determined and the best compromise selected. If a variable flap is contemplated, the range through which it should operate can be determined. The model tests are thus reduced to a usable and convenient form for design. It is to be noted, however, that the drag values are only relative. The actual drag will depend to a large extent on the location of the engine, and its position relative to the wing or fuselage. These matters are secondary to the cowling and cooling and, once the proper cowling shape and size for cooling with the lowest basic drag is determined, the actual drag can be found from a model test or estimated from other available data.

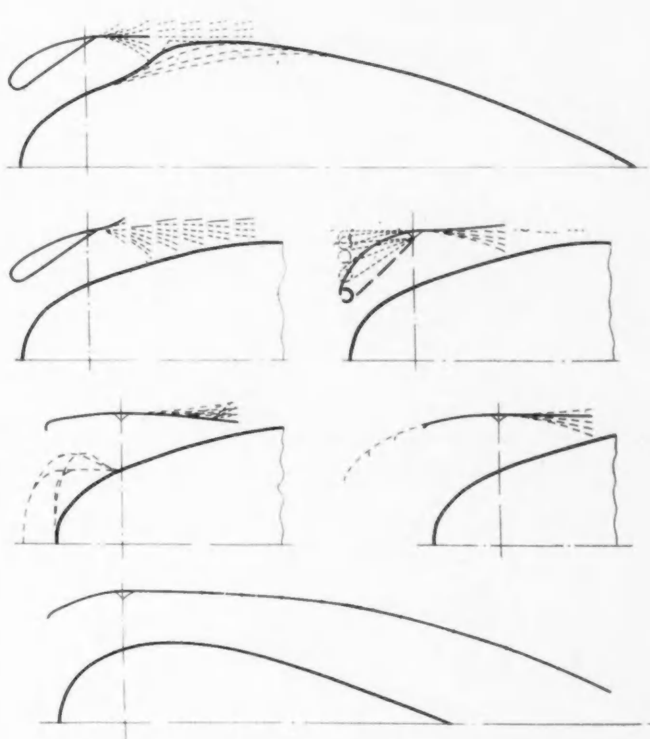


Fig. 3—Cowling Shapes Investigated in the Model Tests

Variables Affecting Engine Cooling

Engine Speed and Manifold Pressure.—The results of several recent investigations conducted by the Committee on the factors affecting the cooling of air-cooled engines are presented at this time since they are of assistance in studying the performance of the air-cooled engine. The question has been raised as to the relative advantages, if any, from the standpoint of cooling, of obtaining a given engine power by operating at low engine speeds and high boost pressures or high engine speeds and low boost pressures. The data presented in Fig. 6 show the results obtained from an investigation of the cooling of a GR-1535 engine in an XO4U-2 airplane mounted in the full-scale wind-tunnel. In this installation the engine was equipped with a geared centrifugal blower and a controllable propeller. A range of overlapping powers was obtained by varying separately the manifold pressure and the engine speed. These data, when plotted on a brake-horsepower basis, show that, for the same power, slightly lower average cylinder temperatures were obtained by varying the engine speed. When plotted on an indicated-horsepower basis, however, the data can be represented by a single straight line. These results indicate that the quantity of heat to be dissipated to the cooling air from a given design of engine cylinder is dependent only upon the indicated power of the engine.

Air Speed and Density.—In the determination of the quantity of heat to be dissipated by a given design of finned cylinder, it is important to know how the heat-transfer coefficients vary with the velocity and density of the cooling air. Experiments conducted by numerous investigators with air-flow around heated pipes indicate that the surface heat-transfer coefficient q — B.t.u. per sq. in. total surface area per

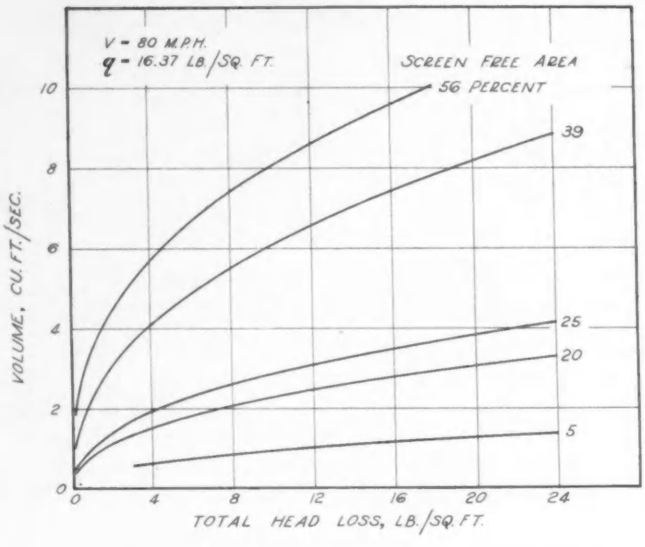


Fig. 4—Curves Showing Volume versus Head-Loss for Different Screens; from Model Tests

hr. per deg. fahr. is proportional to the weight-velocity of the cooling air raised to the exponent 0.8. There are few data available, however, on the variation of the temperature difference of finned cylinders with the weight-velocity of cooling air. For a constant heat-input, the temperature difference between the outer wall of a cylinder and the cooling air is inversely proportional[3] to the overall heat-transfer coefficient U.

Fig. 7 shows a logarithmic plot of the reciprocal of the heat-transfer coefficient, U, plotted against weight-velocity of cooling air. The upper curve shows the calculated results obtained from tests with an electrically heated finned cylinder. The range of values of weight-velocity was obtained by using a Roots-type supercharger to supply the cooling air and varying the air density and air speed. The slope of the curve varies from —0.51 to —0.39. The lower curve shows the results obtained from single-cylinder-engine tests in which a blower was used to supply the cooling air. The dimensions of the fins and the diameter of the electrically heated cylinder and that of the cylinder used on the test engine were approximately the same. The slope of the curve of average temperature differences of points on the cylinder barrel plotted against weight-velocity of the cooling air is —0.4. These results indicate that the temperature difference of air-cooled cylinders is inversely proportional to the weight-velocity of the cooling air raised to an exponent between 0.4 and 0.5. This relationship is of particular importance in determining the change in temperature to be obtained with variation in air density and air speed.

Since the cylinder-temperature difference is a function of the weight-velocity of the cooling air, the cylinder-temperature differences should remain constant for a constant engine power and a constant weight-velocity of cooling air, regardless of what combination of density and velocity is used to obtain the constant weight-velocity. The effect of operating at constant engine power and constant weight-velocity of cooling air for a greater range of air densities and air speeds is shown in Fig. 8. The air speeds corresponding to the maximum and minimum densities were 177 and 287 m.p.h., respectively. The thermocouples on the rear spark plug showed a slight decrease in temperature with decrease in air density, but all other thermocouples showed a constant temperature difference. These results are considered to be a good experimental check on the variation in cylinder-temperature difference with weight-velocity of the cooling air.

Cooling-Air Temperatures.—Since engine tests are not run at constant cooling-air temperatures, it is necessary to know what corrections to apply to the cylinder temperatures for variations in the cooling-air temperature. An investigation is in progress to determine, for a wide range of air-cooled-cylinder sizes and types of finning, the variation of cylinder

[3] See N.A.C.A. 1934 Report No. 488; "Heat Transfer from Finned Metal Cylinders in an Air Stream," by Arnold E. Biermann and Benjamin Pinkel.

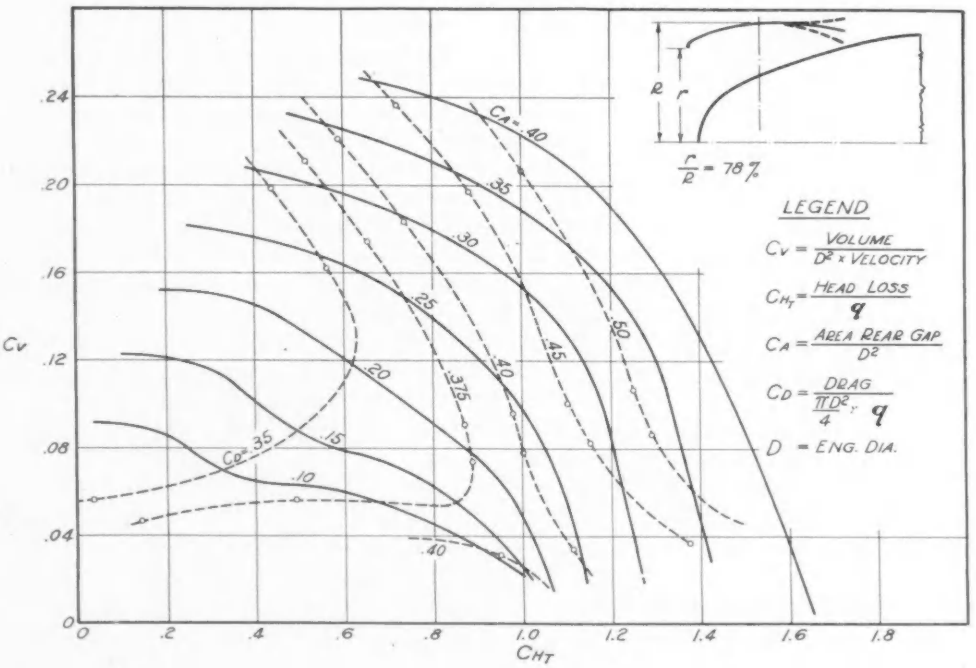


Fig. 5—Typical Chart for Cowling Design

(For illustration only. Do not use for design.)

temperature with cooling-air temperature. Preliminary results of an investigation along somewhat similar lines have been given by Gagg.[4]

The results obtained from tests on the single-cylinder engine with the Wasp S1-H1-G cylinder-design are shown in Figs. 9, 10, and 11. The temperature correction α is the increase in cylinder temperature per degree increase in cooling-air temperature. The consistent value of the correction factor for a range of engine powers, engine speeds, and weight-velocity of cooling air is of particular interest. These results are considered to be preliminary, since they have been determined for only two of the six-cylinder designs that will be tested. The results indicate that for constant conditions of engine power, air-fuel ratio, weight-velocity of the cooling air, and combustion-air temperature for each 100-deg. fahr. change in cooling-air temperature, the cylinder-head temperatures change 80 deg. fahr., the barrel temperatures 75 deg. fahr., and the flange temperature 58 deg. fahr.

The variation in cylinder temperature with variation in carburetor-air temperature has also been investigated with the two types of air-cooled cylinders. The preliminary tests indicate an inconsistent variation in cylinder temperatures with carburetor-air temperature and further tests are being made. The results do indicate, however, that with constant engine-power, the variation in cylinder temperatures with carburetor-air temperature is of the order of 10 per cent of the change in carburetor air temperature.

Single-Cylinder-Engine Tests

Description of Equipment.—The minimum quantity of air required for satisfactory engine cooling was determined from single-cylinder-engine tests. Fig. 12 is a diagrammatic representation of the test equipment. The Wasp S1-H1-G cylinder was assembled on an N.A.C.A. universal-engine crankcase. The crankshaft used gave a displacement of 155 cu. in. for the engine, as compared with one of 149 cu. in. per cylinder of the multi-cylinder engine. The compression ratio of the test engine was 5.33:1.

The cylinder was completely enclosed in a jacket and a blower was used to supply the cooling air. The cylinder jacket was carefully shaped to simulate the design of baffles as used on the standard Wasp S1-H1-G engine. Other jacket shapes giving improvements in cooling over that obtained with the standard baffle were also used. The principal differences between the baffles was the extent of the front opening and the clearance between the baffle and the cylinder fins. The discharge duct at the rear of the cylinder was 6 in. long and the area was twice the free-flow area between the cylinder fins.

The cylinder temperatures were measured by 34 iron-constantan thermocouples made of 0.016-in.-diameter wire. The cylinder head was drilled and the thermocouples peened in place. Thermocouples were spot welded to the steel cylinder-barrel. An insulated cold-junction box was located on the side of the engine. The inlet and outlet cooling-air temperatures were determined from a temperature survey made across the inlet and outlet openings, using chromel-constantan thermocouples.

The combustion air for the boost tests and the cooling air were supplied by Roots-type superchargers driven by electric motors. The carburetor air was measured by a 100-

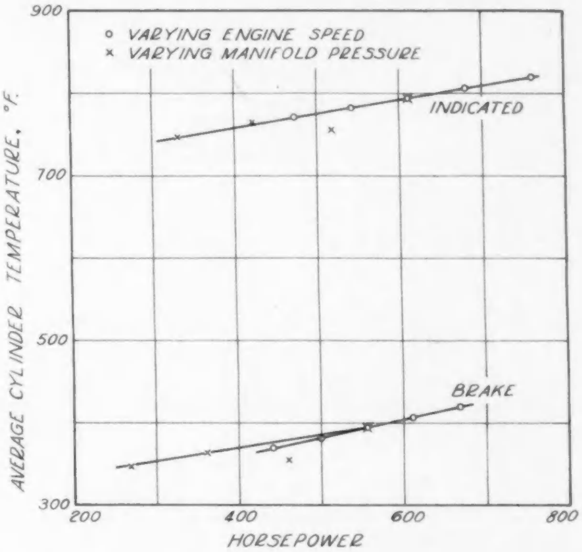


Fig. 6—Average Cylinder-Temperature Differences Obtained for Varying Manifold Pressures and Speeds

cu. ft. gasometer. The duct from the blower to the cylinder was gradually increased in area and a suitable arrangement of screens and baffles was used to obtain a low, uniform velocity of the cooling air in front of the engine cylinder. For the tests in which the air was supplied at densities less than atmospheric, Roots-type superchargers were connected to the discharge side of the jacket and the air was drawn past the engine cylinder. A throttle valve was placed in the air line between the orifice tank and the cylinder. A minimum air density of 0.045 lb. per cu. ft. could be obtained by varying the position of the throttle valve and the speed of the superchargers. For tests in which the cooling and carburetor air were varied, electric heaters were installed in the separate lines.

The gasoline used corresponded to Army specifications Y-3557-6 for 87 octane-number gasoline. For the tests at

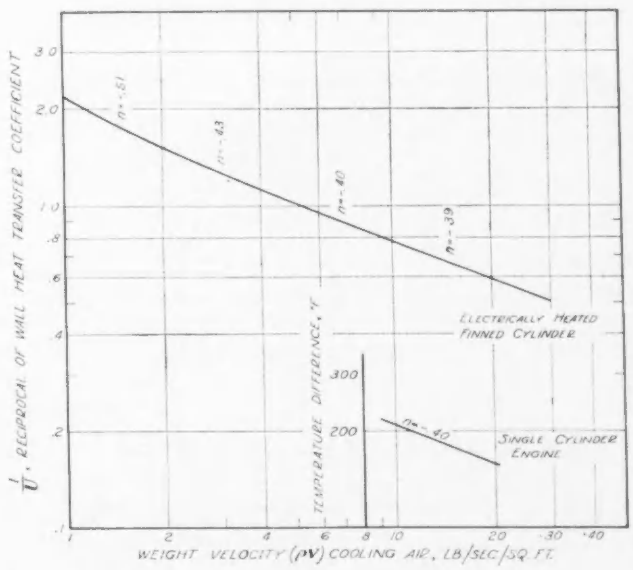


Fig. 7—Variation in Heat-Transfer Coefficient and Temperature Difference with Weight-Velocity of Cooling Air

[4] See S.A.E. JOURNAL, February, 1935, p. 50; "Current Problems in Air-line Engines," by R. F. Gagg.

Cylinder Temperature Correction Factors for Variation in Temperature of the Cooling Air

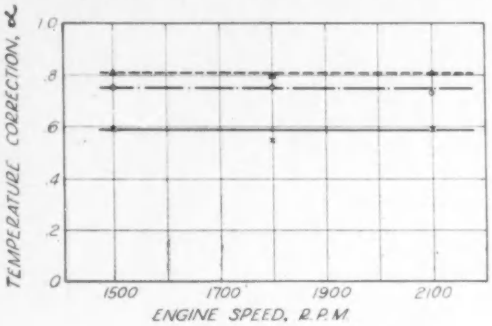


Fig. 9—Effect of Engine Speed
b.m.e.p.—120 lb./sq. in.
b.f.c.—.57 lb./b.hp.-hr.
ρV—23 lb./sq. ft./sec.

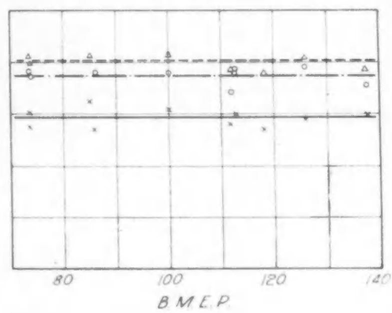


Fig. 10—Effect of Brake Mean Effective Pressure
r.p.m.—1500
b.f.c.—.57 lb./b.hp.-hr.
ρV—23 lb./sq. ft./sec.

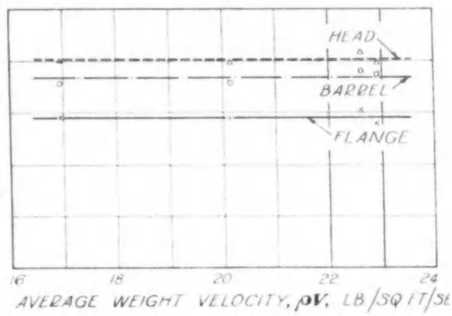


Fig. 11—Effect of Weight-Velocity of Cooling Air
r.p.m.—1500
b.m.e.p.—70 lb./sq. in.
b.f.c.—.58 lb./b.hp.-hr.

high cooling-air temperatures, sufficient ethyl fluid was added to eliminate detonation.

Air Measurements.—Fig. 13 is presented to show the information obtained from the single-cylinder-engine tests that will be used in checking the performance of the cowled multi-cylinder engine in the wind tunnel. The data presented are for a cylinder jacket that has a smaller front opening and less clearance between the jacket and the fins than have the standard pressure baffles used on the wasp S1-H1-G engine. For this reason the pressure drop across the cylinder is considerably higher than that obtained on the multi-cylinder engine with service cowling. The power required for cooling has been calculated for an assumed blower efficiency of 100 per cent. Tests are now in progress to obtain similar information for the standard pressure baffles. Although the pressure drop with the closely fitting baffle is high, the quantity of cooling air required for satisfactory cooling—500-deg. fahr. rear-spark-plug-boss temperature—is decreased so that the power required for cooling may actually be less than will be required with the baffle giving a lower pressure drop.

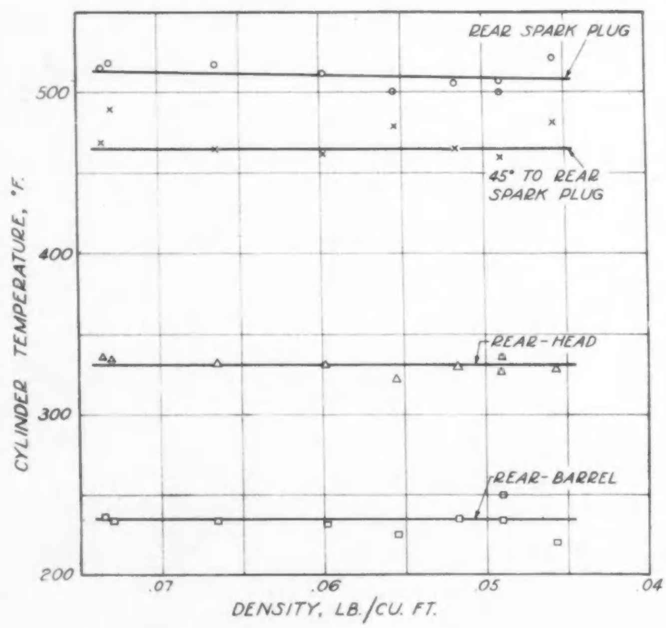


Fig. 8—Cylinder Temperatures for Constant Weight-Velocity of Cooling Air

Check Tests on a Radial Engine

The quantities of air that will flow through cowlings of different shapes with various openings and the corresponding drops in pressure having been determined, in the series of model tests described, and the quantity of air required for cooling a cylinder when developing various powers having been measured, it is necessary to make some check tests on actual engine-cowling combinations. The purpose of these tests is to bring out the differences between model and full scale and between the multi-cylinder and the single-cylinder engine, as well as to determine corrections that may be required to make the simplified test results of practical use.

In addition, the tests of the complete engine allow the determination of the effect of the propeller, which was not present in the model tests. The cooling of the crankcase and the lower portion of the cylinders, which with some shapes of inner cowling are practically covered up, may also be studied. The full-scale tests bring out facts about a number of variables not accounted for in the model cowling and single-cylinder engine tests.

Description of Equipment.—Through the courtesy of the Pratt & Whitney Aircraft Co., a Wasp S1-H1-G engine was loaned to the Committee for use in the check tests. A controllable propeller was furnished by the Hamilton Standard Propeller Co. The automatic speed-control feature of the propeller allows the engine speed to be held constant. The engine was calibrated at the factory before delivery to the Committee.

The tests are being made in the 20-ft. propeller-research tunnel. The cowled engine is mounted on a system of struts on the tunnel balance as shown in Fig. 14. Thermocouples are installed on all cylinders and recording pyrometers are used to indicate and record the cylinder temperatures. Pressure tubes are located ahead of and behind the cylinders for determining the volume and pressure drop, and pitot-static tubes are installed between the cylinder fins to determine the velocities. The pressures are simultaneously recorded photographically by a multiple manometer located in a dark room.

Resistance thermometers are installed for determining the temperature of the air outside and inside the cowling. Similar thermometers indicate oil-in and oil-out temperatures and the thermocouple cold-junction temperature. The oil is cooled by circulating water through oil radiators located inside the cowling. The heat loss to the oil is determined from measurements of the quantity of water flowing through the

radiator and the temperature rise of the water. Flow-meters are installed in the gasoline supply line so that the fuel consumptions may be continuously determined.

Samples of the exhaust gases from individual cylinders are obtained from steel tubes located in the center of the exhaust stack and close to the exhaust valve. The engine and propeller controls and the manifold-pressure manometer are located in the balance house, which is entirely enclosed and supplied with fresh air from outside the building as a safety precaution for the operators. The engine installation in conjunction with the drag balance and the wind-tunnel manometer for determining the air speed are designed to give a complete record of all the quantities of interest in the determination of the power output and cooling of the engine and the drag.

It would, perhaps, have been desirable to carry out flight check-tests, but the complete equipment that can be installed in the wind-tunnel set-up and the controllable conditions would not have been possible. The only advantage of flight tests is a slightly higher air speed, but the 110 m.p.h. available in the tunnel is only slightly below the climbing speed of even the high-speed airplanes. From the manner in which the tests are being conducted, it will be possible to predict the cooling at higher speeds and the wind-tunnel tests are, therefore, altogether advantageous.

Engine-Cowling Shapes.—For economy, the check tests are to be made on a limited number of cowlings. From a study of the model data the relative effect of the numerous changes was determined and, by eliminating from consideration the shapes showing small differences, a series of cowlings was selected that would provide a wide range of conditions and still be representative. The cowling shapes to be tested on the engine installation are illustrated in Fig. 15. Three different front openings, with two shapes for the largest opening, and three rear openings with two inner cowls are contemplated. Since each front opening is to be used with all the rear openings, a total of 17 separate tests is to be made. The inner cowling, No. 2, was not tested in model form, but is included in the check tests as being more nearly representative of cowlings used in practice. A comparison of the results with those from the inner cowling, No. 1, will be quite useful. In addition to the beforementioned tests with the cylinder baffles, some tests are to be made with the baffles removed.

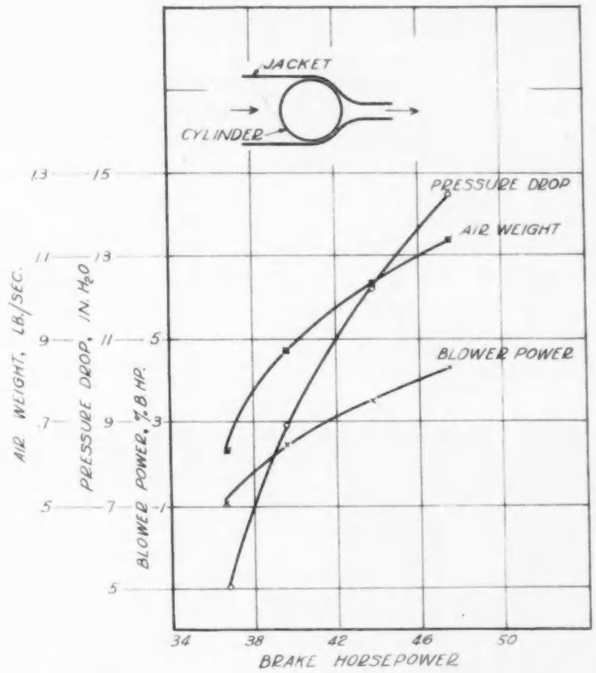


Fig. 13—Cooling-Air Weight, Pressure Drop, and Power Required for Cooling the Single-Cylinder Engine

Test Procedure.—The test procedure was determined from consideration of the quantities to be measured and their relative importance, and modified as the result of experience gained in early tests. It was decided to operate the engine at speeds of 1600, 1800, and 2000 r.p.m. and at air speeds of 80, 100, and 110 m.p.h. At each air speed and engine speed, the manifold pressure is adjusted to give several different powers. The following limits were set on the operating conditions so that the engine would at all times be running in a safe condition: Rear spark-plug temperature, 500 deg. fahr. on the hottest cylinder; hottest point on the cylinder, 550 deg. fahr.; maximum flange temperature, 300 deg. fahr.; oil-in

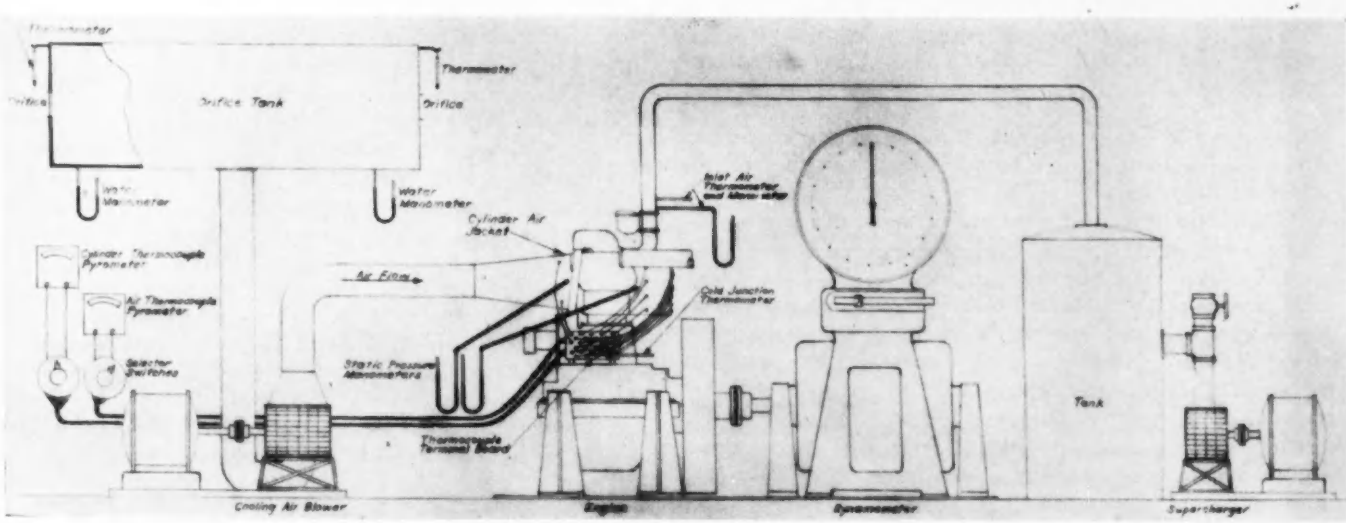


Fig. 12—Arrangement of Apparatus for the Air-Cooled-Engine Investigation

temperature, 140 deg. to 160 deg. fahr.; and oil-out temperature 200 deg. fahr.

The operating procedure is substantially as follows: The engine is started, the tunnel is brought up to speed, and the manifold pressure and engine speed are adjusted. Operation continues at constant conditions until the cylinder temperatures are stabilized. Readings of all instruments are then taken. A new power is then set and the test continues. Should any one of the limiting conditions be reached, the test stops immediately. This procedure, carried through for a cowling, gives data that can be plotted in a number of ways to determine finally the air speed at which the particular cowling will cool with rated power, and at the same time

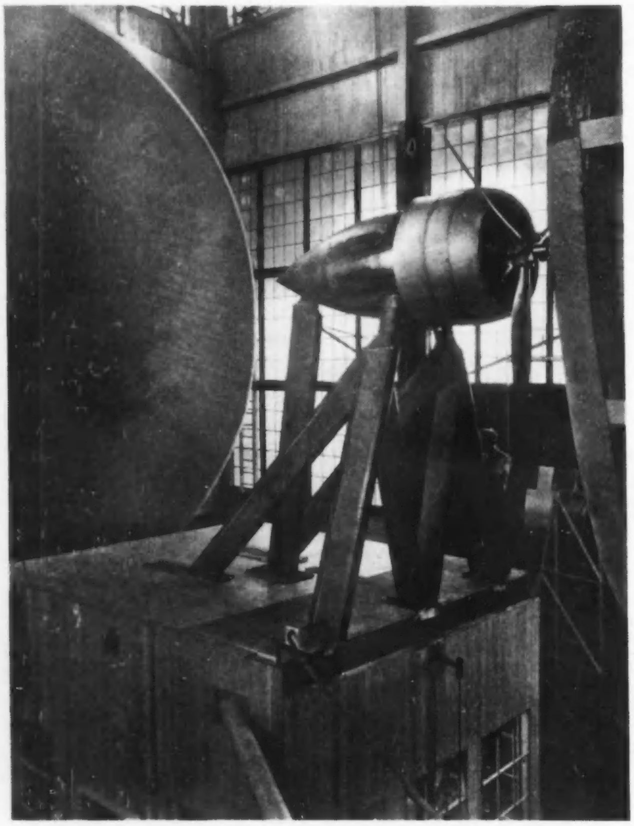


Fig. 14—Set-Up of the Cowled Engine in the Wind Tunnel

shows the effect of a wide range of operating conditions. Although a cowling may not actually cool this engine properly under all the conditions of the test, sufficient information is obtained to determine for what conditions it will cool.

One test is made with the propeller removed at several air speeds to determine the volume, pressure drop, and drag. This is a check of the model tests. A comparison with the results obtained with the engine operating gives the effect of the propeller. Finally, a comparison with the results of the single-cylinder-engine tests is made to determine whether corrections are required.

The procedure outlined yields a great deal of correlated data which are to be analyzed to determine the design quantities for several engine cowlings. The check tests are just starting, but the results to date show good agreement with the prediction from the model tests. For example, from a

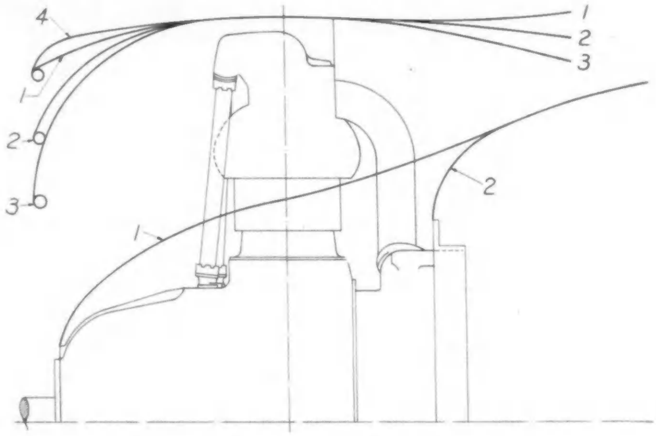


Fig. 15—Cowling Shapes To Be Tested on the Engine

model-test chart similar to Fig. 5 and corresponding to Cowling No. 1, Fig. 15, it was determined that at a speed of 80 m.p.h. the head-loss coefficient for the full-size engine cowl should be $C_{HT} = 1.26$ and the volume coefficient $C_V = 0.064$. The values measured on the full-size engine at the same speed are $C_{HT} = 1.24$ and $C_V = 0.064$.

The operating propeller produces important effects as illustrated in Fig. 16. The total head-coefficients ahead of and behind the cylinders are shown for one power output at several air speeds with the corresponding values obtained at the same speeds with propeller removed. These results were obtained with Cowling No. 1 of Fig. 15. It is to be noted in this case that the total head in front of the cylinder is less with propeller operating than when it is off. The total head behind the cylinders, on the other hand, is more negative, due to the suction at the rear gap produced by the slipstream flowing over the outside, so that the total head difference, and consequently the volume of flow, is greater with the propeller operating. The condition illustrated is not necessarily general and, with changes in front opening and rear gap, the relative total heads may change considerably front and rear.

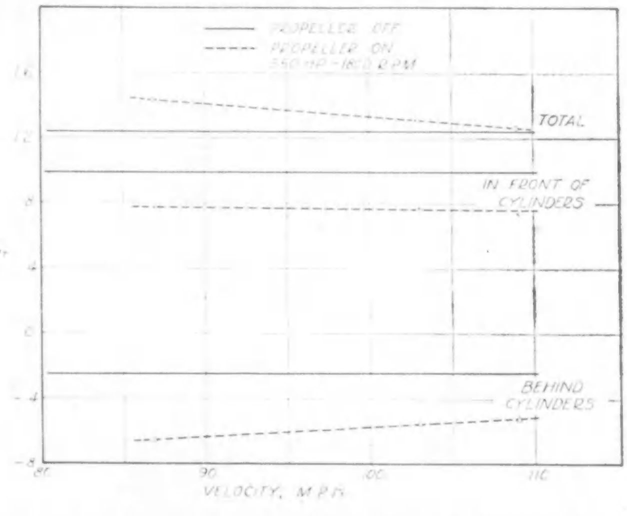


Fig. 16—Effect of the Propeller on Air Flow Through the Cowling

(These values correspond to climbing condition, not high speed.)

Mechanical Mind Reading (Transmissions)

By John Sneed
Sneed Engineering Corp.

THE author gives results of several years' experience in the development of automatic transmissions. Early designs are shown and explained and reasons for changes to present designs are given.

Driver reaction to different types of automatic shifting is discussed and conclusions are drawn.

Graphs are presented showing the acceleration characteristics of different jobs.

A detailed description of the author's latest development in fully automatic transmissions is given.

ALMOST from the beginning of the automobile industry inventors have struggled to produce a mechanism that would eliminate the bothersome labor and uncertainty of gear shifting for the driver. It is with genuine humility that I now attempt to instruct in an art in which so much effort has been expended, with such little success. However, several years ago I too became interested in this subject and determined to find out for myself just why this task was such a difficult one. My one determination at that time, and which has continued since, was to keep an open mind as to both mechanism and performance until such time as I had accumulated sufficient experience to enable me to judge, with some degree of accuracy, the practicality of such a device.

In burdening my readers with a great deal of more or less ancient history of my efforts, my sole purpose is to acquaint them with the changes which have taken place in my ideas on performance, together with the reasons for those changes, that they may better judge whether or not the machine, which I shall later describe, meets the requirements.

My first step was to set down a prospectus of the ideal transmission as I then conceived it, considering, of course, to some extent, the already formed driving habits of some 20 million drivers and the possibilities of economical production. My second step was to acquaint myself as thoroughly as possible with those things which had been tried, at least on paper. A very thorough and expensive search of the patent office yielded literally thousands of designs, all guaranteed by their inventors to be just what the doctor ordered. Copies of these patents were ordered and the real work began.

For a period of months I lived with patents, studying mechanisms and claims but more particularly trying to digest the arguments of the different inventors for each particular design. I was more interested in what might be practical in the way of operation than in the particular mechanical way of obtaining it, as I felt certain that, once the things which should be done were established, means could be found to do them.

The thing which impressed me most in the study of these patents was the failure of most of the inventors to analyze fully the problems involved. Comparatively few have attempted to do anything at all about the time element in changing from one gear to another, and almost all of them have neglected the laws of friction. Lack of flexibility is inherent in many of the designs, and quite a number of them apparently believe that shifting to a lower gear is of no importance whatever. However, one thing I did gain from this study; this was an unwavering belief that the driving public actually wants an automatic transmission, provided it will perform. I cannot understand why, if it were otherwise, so many would try so hard to perfect such a device. The occasional mechanically gifted driver may actually like to shift gears; but, as you are aware, the great majority of the driving public is not mechanically gifted, and to those who are not shifting gears it is just a chore.

I felt at that time, and still do, that the driving public wants a job in which changes in gear ratio are definite, or are step changes, as I believe the average driver becomes a very fine judge of just what performance his car will deliver in any given gear; which of course enables him to do a rather high-grade job of driving most of the time, at least a job which seems high grade to him. However, given an infinitely variable ratio of reduction and his judgment of just what may be expected in the way of performance at any given time may not be so good. Then, too, the fact that more torque at any reasonable road speed causes the engine to race away from the ground speed of the car does not appeal to the average driver. In fact, one of the hardest things to get used to in the type of transmission I shall describe is the dropping into a lower gear at the proper time and under the proper condition without assistance from the driver.

Please bear in mind that what I have tried to do has been to perfect a transmission which enables the driver to continue to drive using practically all of his present driving habits and

[This paper was presented at the Semi-Annual Meeting of the Society, White Sulphur Springs, West Va., June 19, 1935.]

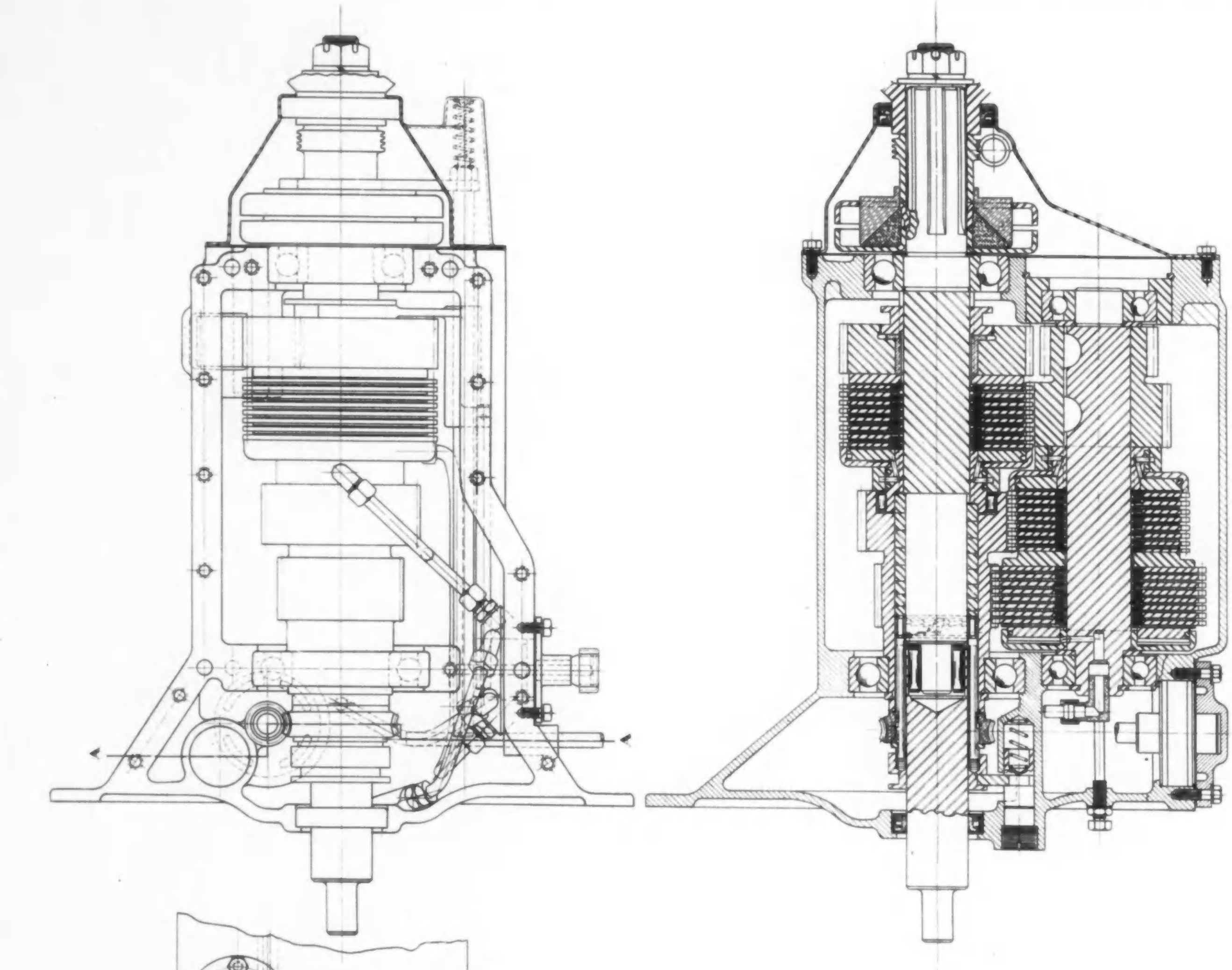


Fig. 1—First Design of a Three-Speed Automatic Transmission Having Constant-Mesh Gears

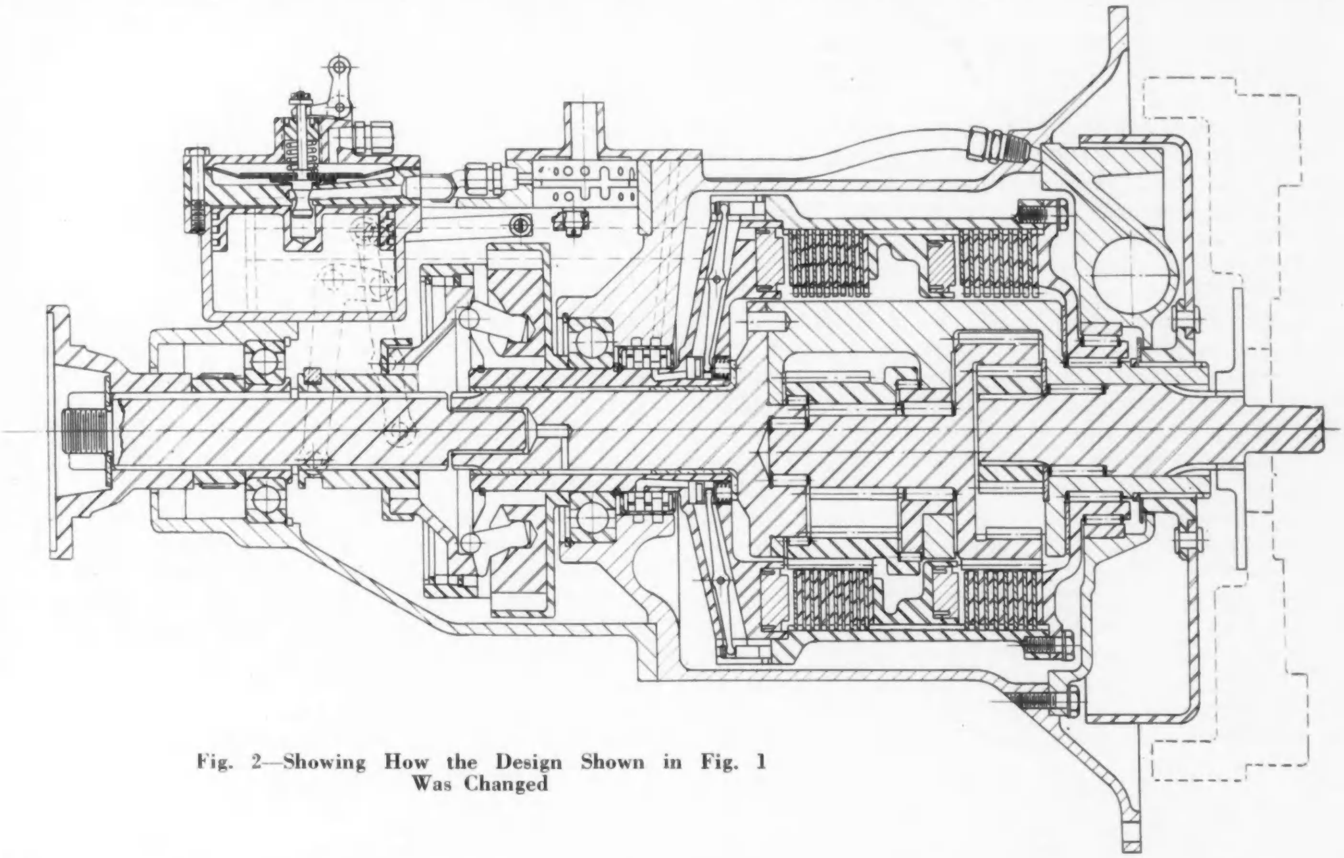


Fig. 2—Showing How the Design Shown in Fig. 1 Was Changed

judgments and eliminating only the labor of putting them into effect. I have observed that the human race is not only willing but anxious to forget work.

These arguments, and others in favor of a stepped transmission, I believe still hold good.

During the early stages of this work I felt very certain that any automatic features of a transmission should be under control of the driver at all times, and that he be able at any time or speed to overrule the automatic selection and, by use of a simple manual selection, use any gear wished. (Very probably the subconscious reason for this opinion was a realization of the unpopularity of back-seat drivers in general and the hunch that a chronic back-seat driver would become unendurable.) This idea has been temporarily discontinued; not for the reason that it could not be done, but because it did not appeal to me personally. I have driven such a transmission for several months and really tried to get some personal satisfaction from this feature and failed. The reason was, to my mind, that proper automatic operation is so satisfactory in so great a percentage of cases, that, when a very special condition arises in which the driver might desire a different gear than the one automatically selected, he is so out of the habit of manual control that the emergency is usually past before he remembers that manual shifting is possible.

I would be gratified if my readers would bear in mind that these are my very personal conclusions, and that they may not be taken as facts. In the matter of automatic transmission apparatus, the public, which buys the automobiles we build, will be the ultimate critic.

I felt quite certain in the beginning of this work that, if a transmission with both these features were available, the changes from one gear to another could be made at certain fixed car speeds. So, after the usual midnight oil over the drafting board, such a design was completed and a job built and installed for test. Although this design functioned just as it was supposed to, I was disappointed to learn, after living with it in all kinds of driving conditions, that it was really just a different kind of manual gear shift, as I drove it especially in traffic. I believe it was this particular job that drove home to me the fact that it is the fellow in the car just ahead who does most of one's driving.

Although the points at which the gear changes were made could be set at different road speeds, it seemed as if the driver of the car up in front just would not be agreeable. If the job was set to change from low to second at 10 m.p.h., he would make his shift at 8 or 12 m.p.h.; and if your transmission was set to shift from second to high at 20 m.p.h., he would either race away in second to 35 m.p.h., leaving you at the post, or loaf along in high at 15 m.p.h. and leave you stuck in second. The net result was that you were forced to shift manually at least 90 per cent of the time in order to save your pride. I decided to incorporate in this job a torque-centrifugal control to eliminate these troubles, and succeeded so well that I also eliminated in my mind the desirability of manual control.

In more clearly explaining this statement let me say that I succeeded so well in providing an automatic control that manual control became entirely unnecessary.

After a man-killing amount of work, a great deal of which was expended in trial-and-error methods, the automatic control of this job began to show such excellent judgment that

the manual control became terribly neglected and, as previously mentioned, was used only by premeditation. In other words, the type of control which is now inaugurated, in my opinion, eliminates any necessity for manual authority over automatic control.

Perhaps these results sound too easy to those who have indulged in transmission work, so let me assure them that I encountered my full share of mechanical difficulties. In fact, while this job was now shifting gears without clashing and was standing up well mechanically, the type of shift it was making was not, to me, entirely satisfactory. With changing temperatures in the transmission oil, the shifts changed, being vicious by trapping kinetic energy when cold, then gradually becoming less positive as the temperature rose until a bad condition of slippage was encountered in the clutches when hot. Stated perhaps more clearly, there was poor control of the time element in these shifts, with the result that, when cold, the time required to complete a shift was entirely too short and, when hot, it was entirely too long, this condition being due to the changing friction of the engaging surfaces. This effect was being found when the pressure which operated the clutches was maintained at all temperatures.

Fig. 1 is a sectional view of one of the first of my attempts at designing a three-speed automatic transmission, having constant-mesh gears. The overrunning gears of this were made up of hydraulically operated clutch-discs, having gear teeth meshing with solid gears on the companion shaft, and having an annular piston displaceable axially of the clutch gears for setting the clutches.

Despite the fact of considerable area and good lubrication, these clutches, due to the multiplied torque loads and the necessity of overrunning or underrunning at all times, failed to stand up as well as anticipated. Increasing their size in this design meant increasing all gear diameters in proportion, and, of necessity, the overall of the gear box, which of course penalized the design in further consideration as a whole. However, the use of gear teeth on the edge of clutch plates seemed desirable both as a weight-saving and a noise-reducing measure, but it was thought preferable to eliminate overrunning and underrunning when in high gear and necessary to obtain sufficient clutch diameter to carry multiplied torque loads without failure.

Fig. 2 shows how the design was changed to obtain this

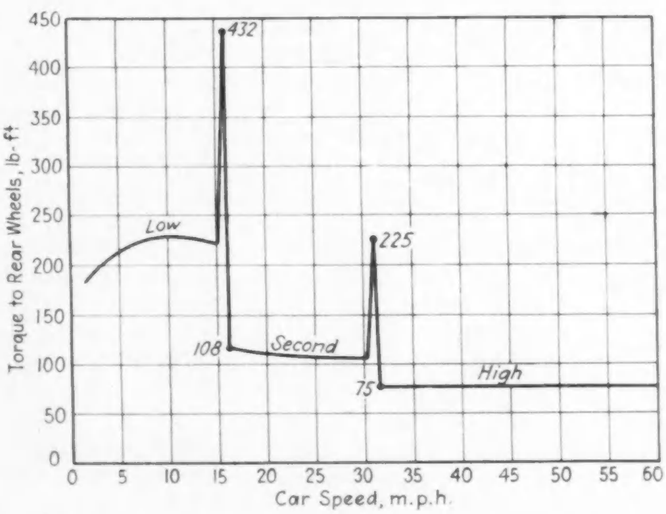


Fig. 3—Probable Torque-Acceleration Characteristics
Engine torque, maximum, 150 lb.-ft. Low-gear ratio, 3:1. Second-gear ratio, 1.5:1.

end. Notice that here also we find the clutch gears, except that they now entirely surround the gear train which has been changed to an all internal external drive design, in which the low speed has a triple reduction and second speed a double reduction to the final drive, or the clutch gears. Here also we have hydraulic operation of the clutches, the one on the right being low, high and reverse, and the one on the left being second. Reaction of the carrier is taken by the brake drum shown at the left. All of these clutch members were operated by hydraulic pressure from a vane pump, which replaced the conventional gear pump on the engine and which was capable of developing pressures to 1000 lb. per sq. in. The drawing shows clearly how clutches of large capacity were made possible without increasing the overall dimensions of the gear box beyond those of conventional types. By increasing the diameter and area of the clutches, I hoped to obtain a much better control of the time factor of the shifts; but I was doomed to disappointment, for early experiences with this transmission were encouraging in some respects and discouraging in others.

The torque speed responsive control of gear changes was very satisfactory. The gear train and clutches showed an unusual ability to "take it", but the hydraulic operation of the clutches failed to please me. In this system the torque is transferred to the propeller shaft through a jaw clutch, the external and internal members of which are helical gears. Tooth loads in this clutch are transformed into axial forces proportionate to the angle of the gear teeth. This force is resisted by centrifugal governors. The external clutch member is fixed to its shaft axially and any relative movement between the clutch members is transferred entirely to the internal member, which is slidably splined to its shaft. Any movement in this member is communicated to the hydraulic control-valve, through a yoke-and-lever arrangement. This valve determines which clutch or combination of clutches shall receive pressure from the pump or what reduction shall be used at the moment.

The governors revolve with the propeller shaft so that, with the car at rest and no governor force available, the valve is forced by torque into the low-gear position and, as the car speed increases, the governor force becomes sufficient so that the sliding clutch member is forced backward against the torque until the distributing-valve inlet communicates with the second speed clutch and an exhaust port is opened to scavenge the low-speed clutch. (I might point out at this time that there are two sets of governor weights, or rather two different leverages for the second and high-speed weights, and that manual control is made possible through a slipping connection between the control yoke and the distributing valve.) It is necessary to carry the same torque or the shift becomes very noticeable. In the conventional manual shift, any roughness or change in torque either up or down is blamed on the driver by both himself and passengers; but when any unpleasantness occurs with an automatic shift, the transmission gets the blame. Due to the fact that the shift occurs without attention of the driver or subconscious warning of the passengers through seeing the driver going through the motions of shifting before feeling the shift in the motion of the car, any marked change in acceleration rate becomes magnified.

Experiences in driving these transmissions taught me that an automatic transmission that failed to do what it should do, at the time it should do it, was just about the most unsatisfactory device which could be built into an automobile, and that automatic shifting to be acceptable must be as smooth as

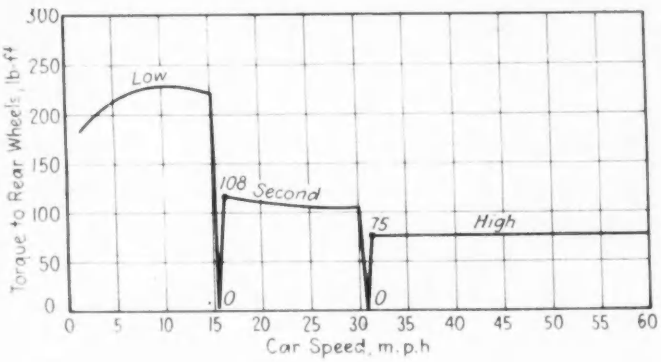


Fig. 4—Best Possible Torque Characteristics of a Conventional Manually Operated Transmission

Engine torque, maximum, 150 lb.-ft. Low gear ratio, 3:1. Second-gear ratio, 1.5:1.

the best possible manual shift, and should be smoother. I also became convinced by these experiences that, before general acceptance of automatic transmissions, someone would have to go all the way on design and build a job that quite literally reads the driver's mind and then does what he wants to do quicker and better than he can do it himself, and that it had to have a complete range of function. One or two automatic features are not enough and partial automatic operation only causes the driver to resent either the automatic or non-automatic operation; and two speeds are not enough, as any loss in performance seems intolerable.

My first efforts toward accomplishing smoothness were directed to very sensitive relief valves in the hydraulic systems of Fig. 2, and was along the lines of supplying the clutches with just sufficient pressure to carry full engine torque, with the thought in mind that anything more than engine torque would cause the clutch to slip. Two facts killed this theory: (*a*) The difference between static and running friction (which is very marked in oil) and (*b*) those shifts made at less than full torque.

One can easily see that, in such a system, if a clutch were set to carry 150 ft-lb. of torque and a shift were made when the engine was only delivering 75 ft-lb. of torque, even with a perfectly uniform friction material, the rate of acceleration would be doubled during the shift until the kinetic energy in the engine was dissipated, at which time the torque delivery would drop sharply, due to the higher gear which the shift had selected. These wide variations and abrupt changes in torque delivery must be eliminated to obtain satisfactory performance.

Figs. 3, 4 and 5, show curves at 75 ft-lb. of torque to facilitate comparison. Fig. 3 shows the probable torque-acceleration characteristics of such a shift. Fig. 4 shows the best possible torque characteristics of a conventional manually operated transmission.

In Fig. 3 we have an acceleration value which varies widely, even though we have frictional engaging means which is set to slip anything more than maximum engine torque. In low, it is 225 ft-lb.; during the shift to second, it becomes 450 ft-lb., which, immediately, upon dissipation of kinetic energy of the engine, becomes 125 ft-lb. in second. During the shift from second to high, this 125 ft-lb. becomes 225 ft-lb. and, again, upon dissipation of kinetic energy, becomes only 75 ft-lb. in high. As previously stated, the most perplexing problem in the design of automatic transmission apparatus is the elimination of these sudden wide variations in torque effort, as transmitted to drive the car.

The graph in Fig. 5 approaches the ideal torque characteristic for a stepped transmission. Note the flatness of the torque curve when compared with the graphs in Figs. 3 and 4.

Fig. 6 is a sectional view of a transmission which is capable of delivering a curve very closely approaching that shown in Fig. 5. In Fig. 6 a three-speed gear box capable of changing gears under either partial or full torque is shown. These changes may also be modified at will by the driver, within certain limits, by manipulation of the throttle to thus modify torque resistance to change in ratio of reduction.

The gear train in this design, while similar in operation to that shown in Fig. 2, has been changed to a semi-planetary type, this change being occasioned by the very difficult bearing problems presented in Fig. 2. A study of the gear arrangement will show the remarkable fact that the only substantial bearing loads in the transmission are only as great as the tooth loads of the pinions, while, in the usual planetary gear train, the pinion bearing loads are usually twice the tooth load. The pinions in this train are driven by sun gears, cut integral with the clutch shaft, and in turn drive ring gears, cut integral with clutch plates. Reaction of the pinion carrier is taken through a roller clutch at the left. The larger of these clutches is the second gear, and the smaller functions for both low and high-gear operation.

The clutch shaft is driven by a master flywheel clutch of the centrifugal type which will be explained later. Operation is as follows:

Upon engine revolutions increasing sufficiently for the master clutch to pick up and start to drive the sun gears, clockwise rotation is set up in both sets of gear clutch plates. The gear clutch plate at the extreme right is perforated to form engagements for a series of small rachet pawls as shown in Fig. 6. These pawls are assembled in the pressure plate for the low-high speed clutch and, upon clockwise rotation of the gear clutch plate, make positive engagement with it and cause it to drive the pressure plate in a clockwise direction. The pressure plate has a number of cam surfaces, which engage like cam surfaces on the housing in such manner that clockwise rotation of the pressure plate forces axial movement to the left, thus frictionally engaging all the clutch plates for low-gear drive. Practically no slippage is possible in low-gear drive, due to the fact that clockwise movement of the low clutch gears in relation to the housing produces engaging movement in the clutch members, all clutch slippage for low-gear engagement being taken by the master clutch.

Torque is thus transmitted through the splined clutch plates to the gear housing, and from the gear housing, through the

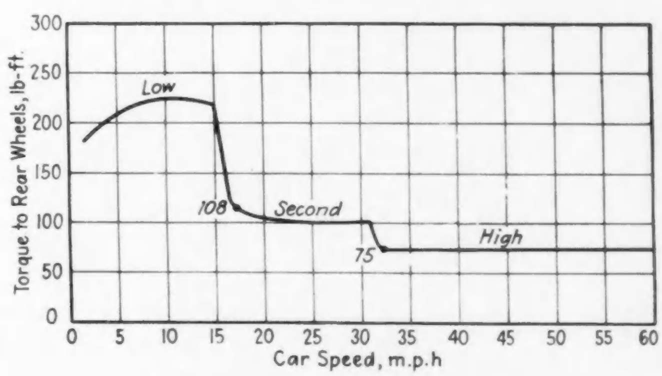


Fig. 5—Graph Which Approaches the Ideal Torque Characteristic for a Stepped Transmission

Engine torque, maximum, 150 lb.-ft. Low gear ratio, 3:1. Second-gear ratio, 1.5:1.

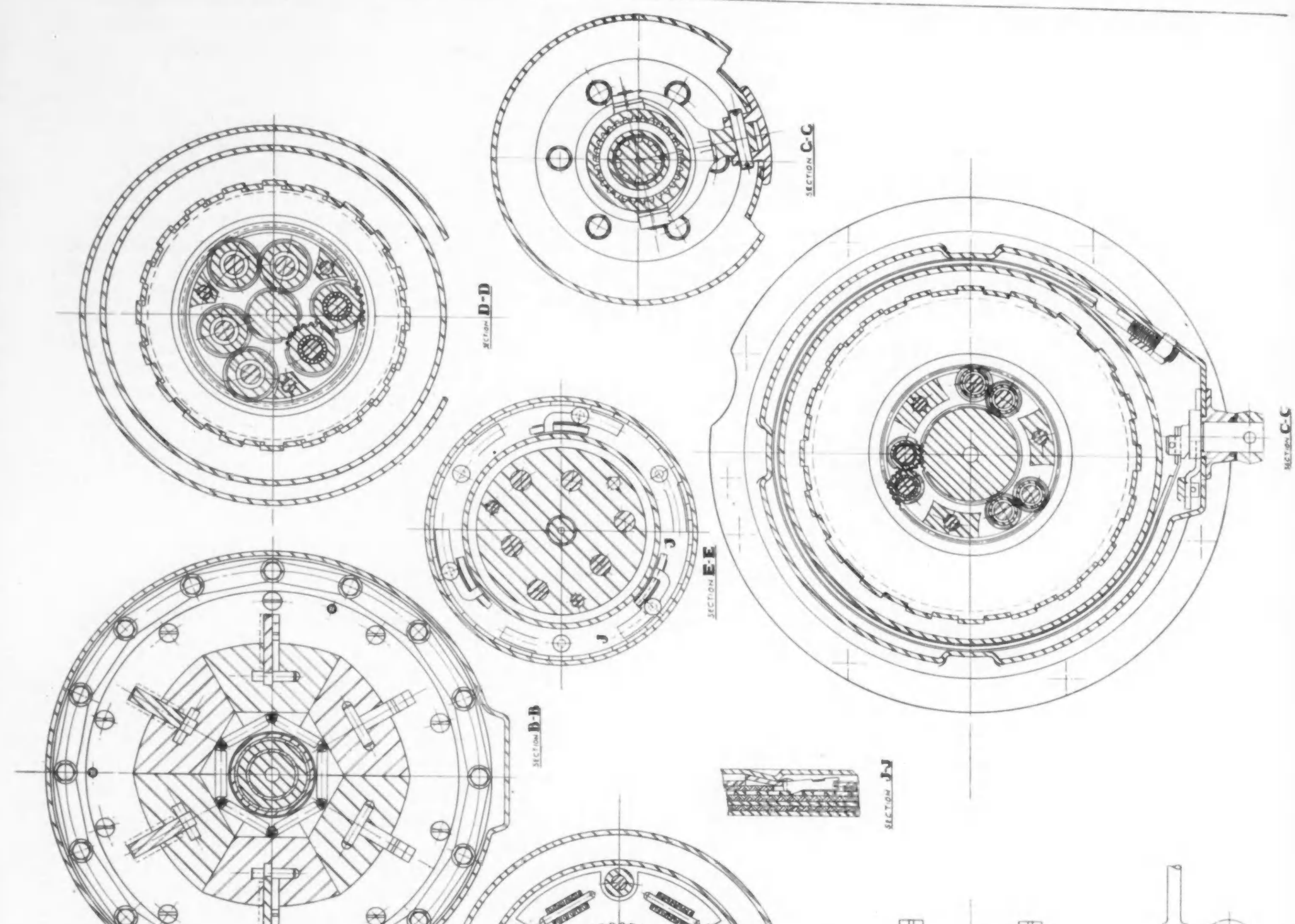


Fig. 6—Sectional View of a Transmission Which Is Capable of Delivering a Curve Very Closely Approaching That Shown in Fig. 5

medium of the pins shown, to the member which we shall call the torque drum. This torque drum is forced by the pins mentioned to rotate with the gear housing, but may slide axially upon it. Torque is transferred from the torque drum through a helical jaw clutch to the final drive. This being a right-hand helix, any torque is proportionately turned into an axial force tending to force the torque drum toward the extreme right. This movement is limited by the centrifugal governors, which are forced into their innermost position. Axial forces due to torque are now balanced and absorbed entirely in the gear housing.

The pinion carrier is now stationary, its anti-clockwise moment being taken into the transmission housing, through the roller clutch. The friction clutches, gear housing, torque drum and centrifugal governors are being driven around it at propeller-shaft speed. The low clutch is positively engaged and the second clutch is running free. When sufficient velocity is established in the governor weights to enable them to move outward against the axial torque reaction of the clutch drum, the rollers which restrain them and the governors move outward on the cams, which operate the second-speed clutch. These cams have four angles which are, alternately, what we shall call resistance and operation angles. The function of the resistance angles is to restrain the governors until such time as they have sufficient power to complete the next shift, without requiring an increase in car speed, and the operation angles determine the actual time element of the shift.

In low gear, the governor rollers are resting against the first resistance angle and inside the pivoting point of the cams. The opposite face of the cam is resting flat against the cover plate of the gear housing, so that, regardless of the pressure on the rollers, no tipping of the cams is possible; but as soon as centrifugal force carries the weights outwardly beyond the pivoting point of the cams, they tip under the axial force set up by torque until all clearance is taken up between the second-speed-clutch plates. Under the urge of centrifugal force, the rollers now continue to move outwardly on the second or operation angle of the cams until the second-speed clutch is carrying just the same torque as was being transmitted by low gear immediately before the shift started. For smooth shifting, the second operation-angle of the cams should be approximately the same after tipping as the first resistance-angle was before tipping.

Fig. 7 is a diagrammatic sketch of this roller-cam action showing how the second-speed-clutch pressure is controlled in such a way as to measure accurately the amount of torque it will transmit during the shift.

A study of Fig. 7 will show that any given torque force will restrain the governors with a proportionate radial force until the engine accelerates the car and the governor weights attain sufficient power to move outwardly against the axial force of the torque, at which time the second-speed clutch is engaged. The force of this engagement increases as the rollers carried by the governors move farther outward until the second-speed clutch begins to drive the gear housing, at which time it starts to run faster than the low-speed-gear clutches. Under this condition the low-speed-gear clutches disengage, due to their anti-clockwise rotation in relation to the gear housing.

Any tendency of the second-speed clutch to transmit too much torque results in the governor weights being forced inwardly along the operation angle of the cams until the pressure on the clutch plates is relieved sufficiently to permit slippage. This slippage occurs in every shift and is always in exact proportion to the excess revolutions of the engine at the moment of shift. Stated more clearly, the power value wasted through slippage of the engaging clutch represents exactly the same value as is present as kinetic energy in the surplus revolutions of the engine. Lowering of engine torque through manipulation of the throttle enables the driver to select the next highest gear at will, and shifts made by this method very closely resemble a well-executed manual-shift made with a conventional transmission.

The shift from second to high is very similar in principle to the one just described, although, in making this change, the second-speed clutch is left in engagement and the low-high speed clutch is forced into engagement too. This engagement is not positive as was the low-speed engagement of this clutch, due to the fact that the direction of rotation of these clutch plates in relation to their housing has reversed. The torque drum is forced forward by the governors until the pins which transfer torque from the gear housing to the torque drum supply the necessary pressure to operate the clutch. This re-engaging of the low-high speed clutch forces the pinion carrier forward against the reaction of the second-speed gears and places the mechanism in direct drive, in which all of the parts become stationary in relation to each other.

Shifting down consists of a reversal of conditions. If in high gear, the power value of the governors through their various leverages becomes insufficient to hold the low-high clutch against slippage; the engine races until the ratio of engine speed to car speed is that of second gear. (The second-speed clutch still has an operating pressure that is at least the equivalent of the axial force set up by the engine torque.) Due to the fact that most of the torque that is now being transmitted is transmitted through the second-speed gear, the reaction of this torque is transmitted to the gear carrier, forcing it to reverse its moment of rotation and establishing a reaction point in the transmission housing through the roller clutch. As soon as this reaction point is established, the axial force of second-speed torque is available to operate the second-speed clutch and to force the full release of the low-high speed clutch by forcing the governors entirely into their second-speed position.

The only manual control for this transmission is the reverse shift, which is accomplished by the use of the foot pedal formerly used for the clutch. Depressing this pedal accomplishes four things, the first being to move the sliding jaw clutch into the neutral position as shown; the second, to release the roller reaction clutch and hold it out of engagement; the third, to engage the jaw clutch member mounted on the tail shaft of the gear carrier; and the fourth, to apply

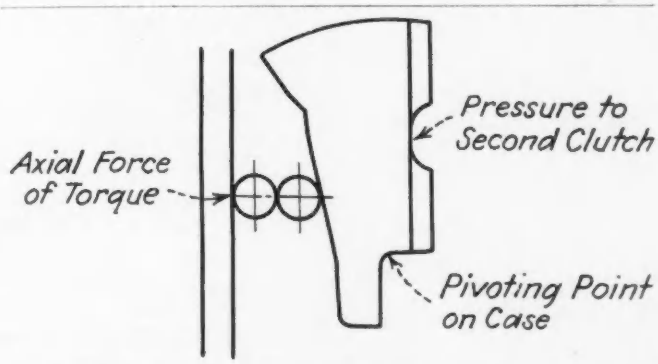


Fig. 7—Diagram Showing Roller-Cam Action

the reverse reaction brake band. The reaction brake band, by holding the torque drum against rotation, forces the torque moment of the engine to reverse its direction in the carrier, thus establishing reverse drive through the low-gear clutch. Release of the pedal reverses these operations and re-establishes forward drive.

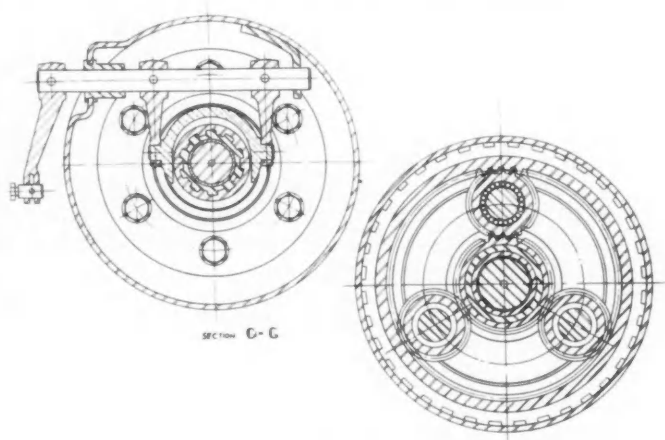
All housings of this transmission are made from pressed steel, and ordinary commercial limits and tolerances are used. There are no difficult production problems involved in any of the parts. All driving gears are helical and very quiet in operation. Fine pitch and low helix angle are recommended. The weight of the complete equipment compares very favorably with conventional transmission practice, and room requirements are about the same.

Fig. 8 shows the overdrive developed for this job. In this design a planetary gearset replaces the sliding jaw clutch for reverse, and the sun gear is slidably splined to the universal joint. Torque is transferred from the transmission proper, through the torque gear, to the pinion carrier of the planetary set. The sun gear of the planetary set is journaled on the torque gear and is restrained from overrunning it by a roller clutch. Forward drive is transmitted in equal amounts to the ring and sun gears by the pinions; but, due to the restraint placed upon the sun gear by the roller clutch, the whole assembly turns as a unit at the same speed as the torque gear or the torque drum. Mounted on the sun gear is a friction clutch disc for engaging the overdrive ratio, which is accomplished by stopping the sun gear and holding it against rotation. The pinions are now being driven around the sun gear, thus imposing a greater speed on the ring gear than that of the torque gear.

The power for operating the overdrive is obtained by use of a vacuum cylinder, and is so controlled that the overdrive may be entirely locked out, may be made entirely automatic and responsive to road requirements at all times, or may be engaged in such way that all transmission speeds are transferred through the overdrive. These changes may be accomplished at any time or at any speed.

To obtain reverse, the whole overdrive unit is shifted backward until the pinion carrier is out of engagement with the small gear, which acts as its driver on the torque gear—this gear being the same diameter and pitch as the sun gear of the planetary set—and the pinions engage both this drive and the sun gear. A plate, which is mounted on the pinion axles and has clutch teeth stamped on its outer edge, engages teeth on the inside of the housing and holds the pinion carrier against rotation, as the drive is now directly into the pinions and their axles are held against movement. A reverse drive is imparted to the ring gear at twice the reduction. Due to the fact that the transmission is allowed to function exactly as in forward speed, the automatic changes in gear ratio occur in reverse in the same way, giving three reverse speeds, but at twice the reduction of corresponding forward speeds. This shift is accomplished by the use of a foot pedal.

Forward control of the overdrive may be accomplished by a push-pull button on the dash, which operates a valve on the vacuum cylinder. With the button in the inward position, vacuum is cut off from the cylinder and the car is in direct under all conditions. With the button in the intermediate position, vacuum is allowed in the cylinder only when the vacuum in the intake manifold exceeds a predetermined amount, which in the present jobs is 2 lb. per sq. in., and



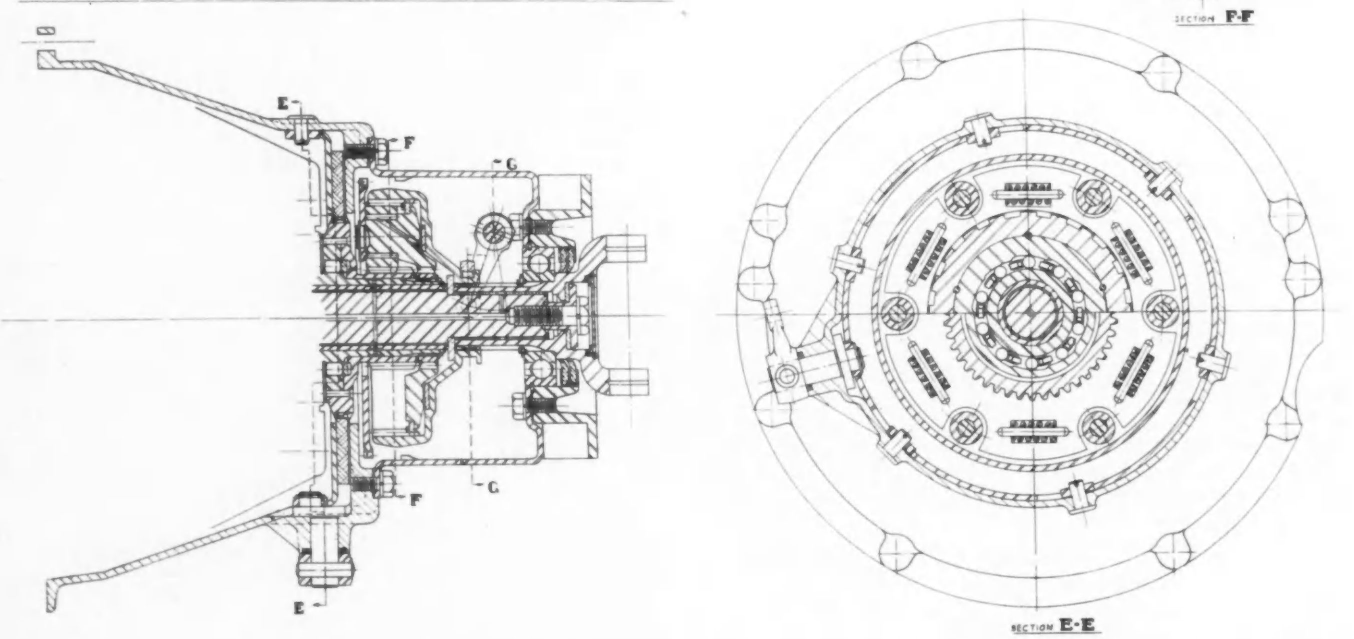


Fig. 8—Design of the Overdrive

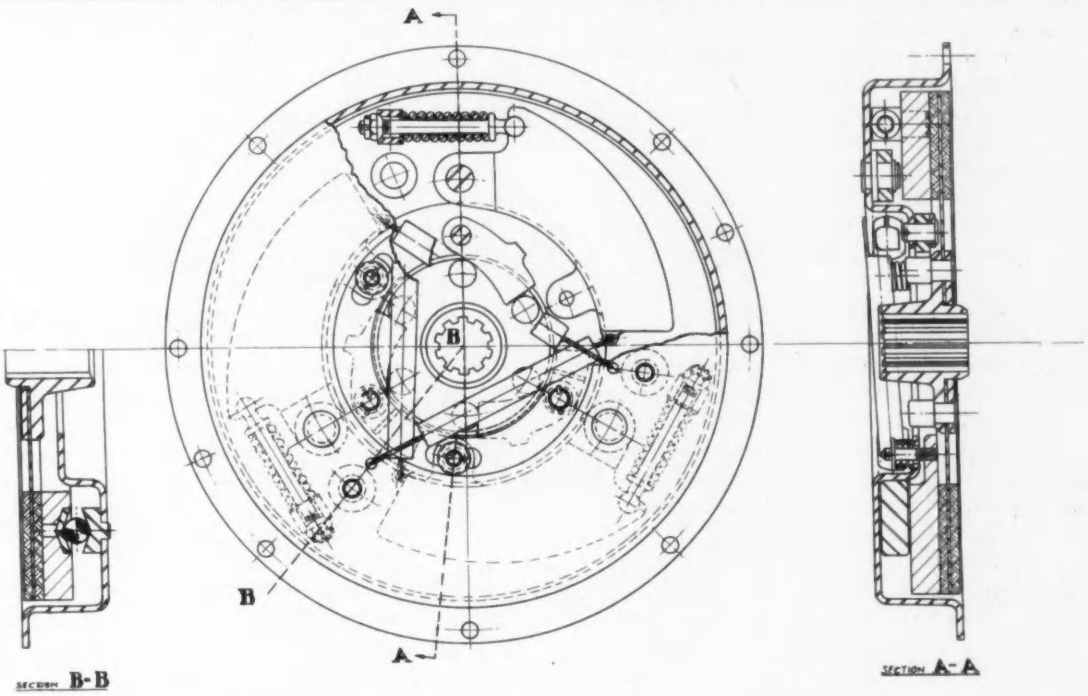


Fig. 9 — Unusual Design of Master Clutch

when the vacuum is cut off by the valve, the cylinder is opened to atmosphere.

A vacuum of 2 lb. or more is required to operate the overdrive clutch, and this valving arrangement is preferable in order that the overdrive clutch may be either entirely free or entirely operated without long periods of slippage when the button is in automatic position.

With the control button in the automatic position, partial throttle opening of the engine produces more than the required 2-lb. vacuum in the intake manifold and, consequently, in the overdrive operating cylinder, and the overdrive is engaged. This engagement of overdrive may occur even when the transmission is in low or second gear, so that if low acceleration is desired, as indicated by the partial throttle, the effect of the overdrive is to change the complete range of overall ratios from engine to rear wheels. However, at any time or in any transmission gear, if the throttle is opened, and the vacuum in the system drops below the required 2 lb., the overdrive is released, re-establishing the conventional overall ratios with, of course, better acceleration, which the driver has indicated he wished by his operation of the throttle. All of these changes occur under torque loads and independent of car speed.

With the control button all the way out, a one-way valve comes into effect. This valve allows the maximum intake vacuum to be established in the vacuum cylinder, but does not allow the cylinder to be opened to atmosphere except by a return of the control button to one of its other positions, so that, until manually released, the overdrive is held positively engaged by the maximum intake vacuum which was established after the button was moved. This also gives a complete change of overall ratios in all gears.

I wish to emphasize the fact that any of these conditions may be selected at any time and at any car speed and without interruption of driving torque.

In my opinion the overdrive is one of the real improvements in automobiles and certainly deserves a place. It appears to me that the initial cost of such equipment should be measured against the resulting economy of fuel as well as against the pleasures of driving an overdrive. If this is done, overdrive becomes one of the best improvement investments to be had on a modern automobile.

Fig. 9, the master clutch used with this transmission, is of very unusual design. It is operated by centrifugal weights, which are hinged on the clutch housing. These weights are connected to the pressure plate of the clutch by means of tension rods and compression springs, and when the revolutions of the engine become great enough to cause the weights to move outwardly against their retractor springs, they force the pressure plate to advance faster than the flywheel. The pressure plate carries three hardened cones and, directly opposite the clutch housing, carries three like cones, with ½-in. steel-balls in between. As the pressure plate advances in relation to the flywheel, these cone-and-ball cams force it toward the flywheel and apply the clutch.

A study of the clutch will show that the pressure plate advances at a 20-deg. angle to the flywheel, this being the angle of the cones used. By this method the governor weights are required to carry one-half the torque of the drive and to supply the axial pressure required to carry all of it. The torque drag of the driven number is at all times trying to return the weights inwardly against centrifugal force. This distinct unenergizing effect produces exceptionally fine engagement under widely varying conditions of friction, and permits the use of weights heavy enough so that the difference in r.p.ms. between full release and full engagement is very low.

Much has been said both for and against automatic transmission and, in my opinion, the things which have been said against it have always had in mind the limitations of one particular system. The system I am describing has only two limitations; (a) the speed at which the system will revert to second under full torque and (b) that braking against the engine is only feasible in the high gear-ratio.

One point I most certainly should point out in connection with this system is the fact that, although considerably better acceleration characteristics are obtained with it than with

the conventional transmission, it is impossible to race the engine above its proper r.p.ms., as any attempt to do so only serves to select the next highest gear, which, in turn, reduces the r.p.ms. of the engine.

Let me call attention to two facts in connection with this job. First, that a three-speed transmission of this design compares favorably with the conventional transmission in cost. Second, that this automatic transmission with overdrive is considerably lower in cost than is a conventional transmission and overdrive, although, when I entered this field of research, I was not positively convinced of the desirability of the automatic-transmission apparatus and was determined solely on a course of inquiry. My experience with this particular design has been so productive of happy results that I am convinced that the next major improvement in automobiles is bound to be automatic transmission.

One point which I have failed to elaborate in this paper is the amount of work done in shifting gears manually. One of our premier brake companies estimates the number of stops as eight per mile in average driving. This figure, no doubt, is arrived at after lengthy test procedure and, if this is true, the smallest number of shifts would be 16 and the greatest number would be 24 shifts per mile. This seems like an entirely unnecessary amount of work for the driver and, inasmuch as better performance can be had with automatic operation and at a cost to compare favorably with the cost of conventional equipment, why not?

Discussion

Other Features of Successful Automatic Transmission Stated

—S. O. White
Warner Gear Co.

IN his paper, Mr. Sneed makes a distinct contribution to the state of the art in automatic transmissions for automobiles. Even though we may not agree in all particulars, we must respect the opinions Mr. Sneed has expressed, and state frankly that the majority of his experiences and conclusions parallel our own.

There has been a revival in power shifting lately, and we have seen some very clever automatic power shifts, usually vacuum operated, applied to more or less conventional transmissions. There are, however, always some objections, and we seem to be so near to a practical solution of the complete automatic transmission that our interest in power shifts is waning.

The general operation requirements that Mr. Sneed has laid down we believe to be mostly correct. We do not expect ever to find general agreement in all respects, and undoubtedly there will be several practical solutions to the problem. It will be a matter of personal opinion as to which solution one prefers.

The factor which most inventors, and also engineers, seem to lose sight of, in their enthusiasm for what may be a most ingenious and intriguing mechanism, is, that it is of no use whatever if it cannot be sold. Usually there are inherent complications and manufacturing difficulties which affect reliability and run the cost beyond the ability of the low-priced or even the medium-priced field, to absorb.

We believe that the successful automatic transmission will have to be a practical compromise, with a certain amount of control left with the driver. We do not believe that Mr. Average Driver would like a fully automatic device, making shifts at the theoretically correct time. He wants to shift when he wants to shift, even though he may be wrong, and will not like the effect if a shift occurs when he does not want it or expect it.

We agree that, in the present state of the art, a stepped-ratio transmission seems most practical, and most emphatically there must be more than two speeds. We have always advocated four.

We can conceive, however, of an infinitely variable transmission having a definite starting ratio, varying up to a ratio comparable to the third speed of a four-speed transmission and stopping there for town and traffic driving. The top speed would be a cruising gear for country driving and attainable only beyond certain speed limits.

Considering now the extent to which the transmission should be automatic, it appears to be feasible to have it fully so from first up to third, which last would be a town or traffic ratio.

It then seems to be essential to have convenient manual means, such as a floor button convenient to the left foot, for putting the transmission back into second and even into low and keeping it there, regardless of car speed or torque.

For reasons of safety, as well as convenience, it should be possible to do all traffic handling with both hands on the steering wheel, all the time.

It seems most practical to do the parking manually. The convenient arrangement is a substantial knob on the instrument board, with three in and out positions providing forward, neutral and reverse.

The most popular means for determining the gear ratios has been the engine torque. This may be partly on account of the many available ways of employing it, and partly because it is a correct measure of the gear reduction needed at the moment. We, however, have yet to see a torque-controlled device that is satisfactory to the driver. One very disconcerting characteristic is that of dropping out of high to a lower speed at unexpected and annoying moments, when the driver had pushed a little on the accelerator for the purpose of moving the car along and not for the purpose of getting a lower speed. Our experience is that a car should remain in high at least as far down as 10 m.p.h. on deceleration, and not shift to a lower gear with moderate pressure on the accelerator.

Another popular means for determining the gear ratios is some form of governor operating in proportion to car speed. As brought out in the paper, this also has disadvantages. One of them is the very real difficulty of designing a governor with sufficient power to operate any mechanism at slow speeds without having plenty of weight, momentum, space, and vibration troubles at fast speeds.

There seem to be some practical possibilities in the way of a control combining speed with torque.

As to the overdrive, this provides the fourth speed for cruising purposes, already mentioned. Mr. Sneed has a very ingenious provision for this, with optional controls to suit almost anyone.

We feel that, for the average driver, it should be automatic and speed controlled. Theoretically, the manual overdrive is correct and most suitable for the expert driver who knows what it is for and how to use it. But it has been well demonstrated in the past that the average driver either will not or cannot use a manually operated fourth speed to advantage.

Rustproofing and Paint-Adherence Technique Analyzed

By F. P. Spruance
American Chemical Paint Co.

EXTENDING the life of those parts most quickly destroyed by corrosion, an important problem in the automotive industry, for practical purposes resolves itself into preventing the failure of paint on metal surfaces.

The porosity of the paint films permits moisture to get through to the metal, and thus to induce electrolytic rusting. Chemically cleaning before painting retards paint failure. Coating the metal with phosphates gives better protection still, by permitting thicker coats of paint. This phosphate surface is not ductile, though, and breaks when the metal is bent, causing paint failure.

Best protection is obtained by first plating the steel with zinc and then converting this plated surface into a zinc phosphate, so that the paint will adhere to it. The next best method is plating steel with a continuous coating of zinc phosphate by means of alternating-current electrolysis.

A chromate treatment known as the Cromodine process has been developed, producing a chromate surface on the steel at a low cost. This coating is as elastic and as ductile as the steel itself; it forms a perfect bond with paint, and is very effective in increasing the life and durability of paint, lacquer, or enamel finishes.

FROM the very beginnings of the automotive industry, even back in the horseless-carriage days, the battle against rust has held a place of high importance. We all have realized that nature must be beaten at her own game; that ways and means have to be developed to prevent the structures we have created from crumbling before our eyes and reverting to their original state. Bringing this general observation nearer home, we have found that our specific problem lies in finding methods to extend the lives of those parts that are most quickly destroyed by corrosion, so that they will equal as nearly as possible the lives of the more durable members. In other words, we soon directed our efforts toward duplicating that famous one-horse shay.

Naturally, our first thought to solve this problem was to paint the exposed parts. Covering the steel with an organic coating is necessary to give the product a pleasing appearance. Why would not paint also, by covering the metal, protect it from attack by rust?

Unfortunately, paint fails in this dual role. We have found that finishes, no matter how well applied, are sufficiently porous to permit moisture to get through to the metal surface. And moisture on the surface of steel is all that is necessary to allow rust to develop. In the electrolysis that takes place, iron dissolves at countless anodic points on the surface, and plates out, even under the paint and primer films, as rust around countless cathodic areas. This battery-like action goes on in a continuous cycle, stopped only by the removal of the electrolyte, or the moisture; or by increasing the resistance of the surface so that the electrolytic action is prevented.

Automotive parts need decorative finishes. Since the organic coatings used for this purpose permit the metal to rust beneath them, and by rusting to cause the finish to peel and crack off and thus destroy its utility as either a protector or a beautifier, our problem in preventing the corrosion of the basic steel, for practical purposes, has resolved itself into prolonging the life of the finish. This means, of course, that ways have to be found to prevent the base metal from rusting, and that we have to improve the bond of the decorative finish to the metal.

In approaching the problem we must realize that, while rust will develop on perfectly cleaned steel, the corroding process is greatly accelerated on surfaces that are not chemically clean. Traces of pickling acids and their salts are always left on cold-rolled steel. These only need a little moisture to convert them into active rusters; and this moisture is always available because of the porosity of the paint films. Even more active rusters are applied to the metal in the soldering fluxes used in metal-finishing operations. Also not to be overlooked as rust accelerators are body acids from perspiring workmen's hands and bodies; and the deposited traces of alkalis—calcium and magnesium salts—from evaporated rinse waters. The presence of these many different rusters explains why a finish that was applied to a presumably clean steel surface can

[This paper was presented at the Production Meeting of the Society, Sept. 18, 1935, Cleveland.]

quickly be ruined and rendered unsightly because of the formation of rust beneath the paint film.

Deoxidine

It was to remove and destroy these various objectionable rusters that the Deoxidine type of cleaner was developed. This treatment, using a phosphoric-acid and oil-solvent mixture, not only cleans off rust, oil, and the visible rusters, but it also destroys the invisible accelerators, so that these can not develop rust under the applied finish. Then too, the phosphoric acid in some types of the treatment leaves a thin coating of phosphates on the metal. This further serves to increase the life and durability of the paint coating. However, this phosphate coating, being thin and smooth, offers only slight additional protection, and it does not materially improve the paint bond or increase the thickness of the paint film.

The development resulting in cleaning steel with Deoxidine was an important step forward. It made synthetic finishes possible, by the complete removal of oils; and it was in a large measure responsible for the marked progress that has been made in recent years in preserving the paint on automobile bodies. By no means outstripped by progress, Deoxidine cleaning is more necessary today than ever, because without it the rust from the extensive soldering required in present body construction would soon ruin the finish.

Bonderite

While the Deoxidine cleaning process has proved highly efficient for general body work, the rough treatment certain parts are subjected to—notably fenders, wire wheels, radiator grills, and lamps—demands a more complete treatment to prevent paint failure. To provide a stronger bond for these parts, the action of phosphoric acid has been increased by the addition of activators.

The Dip-Bonderite process is a notable example of this treatment with activated phosphates. It uses a boiling solution of manganese dihydrogen phosphate, with a small percentage of copper phosphate added. A 3 to 7-min. dip deposits a crystalline coat of mono-hydrogen phosphate of iron and manganese, with traces of metallic copper. This deposited coat retards rusting and, by reason of its crystalline structure, makes a strong bond with the enamel primer. The etched surface produced in the process means that the effective or average thickness of enamel is greater than on a smoother surface; so that, even though the Bonderite coating has little rust resistance, it is an important rust preventer because it permits thicker paint films. Furthermore, when scratches break the enamel applied over this pre-treated surface, rust does not develop far from the scratch.

Spra-Bonderite

The treatments and processes that have been discussed up to this point may be considered old and established, and, withal, somewhat antiquated by the methods of rust-proofing recently put into commercial practise. It is with these recent developments that we are principally concerned.

The newest process to be offered to the automotive industry is the Spra-Bonderite, a modification of the dip process in which a solution containing zinc phosphate is sprayed on the steel after the surface has first been freed from all oil and grease. It is reported that this spraying operation requires a minute, more or less, depending on the temperature of the solution used. The phosphate coating formed is next rinsed with plain water, then with hot water containing chromic acid to speed drying and counteract the objectionable alkalis in the water. The coating that forms on the metal as a result of this process is claimed to compare favorably with that produced by the dipping method, and the cost for chemicals is said to be lower.

The Spra-Bonderite process is a new one. How effective it will be in extending the life of enamel finishes in general production can only be proved by time and experience. It is reported, though, that the process has been in operation on a production basis for some time in one of the supplier's plants.

Despite their ability to add to the life of applied finishes, most phosphate coatings have the weakness of being sufficiently soluble not to be entirely rust-resistant. Therefore, if applied to parts that must be stored or shipped before painting, rust is likely to develop. Another general fault is the lack of ductility and the brittleness of all phosphate coatings. This lack of ductility causes paint failure when the surface is bent or buckled. Many instances of this have no doubt been seen where fenders hit on the tip have buckled several feet away, and the coating has cracked at the buckle, exposing the metal surface to rust.

Electro-Granodine

There is a type of phosphate coating that has been developed recently that is extremely rust-resisting, and consequently lends itself readily to the shipment of parts unpainted. This coating is developed in the Electro-Granodizing process. As the name implies, it is an electrolytic treatment; and an unique one, in that the Granode coating is developed from an electrolyte of zinc phosphate by an alternating current. A direct current, as usually used to deposit metal coatings, would plate zinc on steel surfaces suspended in the Granodine solution; but with the alternating current, the metal is coated, not with zinc but with a continuous coating of zinc phosphate.

The process is a simple one. After oil and grease have been removed with alkalis, or by vapor degreasing, or by a wipe with solvents, the work is suspended on plating hooks in the heated Granodine solution, and the Granodizing current is passed through the electrolyte and the work to be coated.

The Granode coating formed has high dielectric resistance. It builds up on an area until the resultant resistance prevents the formation of additional deposit, with the result that a coating of uniform resistance and uniform thickness free from pin-holes is developed over the entire surface.

Fig. 1 shows the installation for Electro-Granodizing refrigerator cabinet panels in the plant of the H. H. Ward Co., Chester, Pa. The two tanks in the foreground are for rinsing. The tank in the background from which the workman is removing materials is the Granodizing tank. In the left background is the Granodizer. This small unit will serve to coat 1000 sq. ft. of surface per hr.

The essential plating operation takes place in an ordinary steel tank equipped with steam coils for heating the Granodine solution. Steel or wooden tanks are used for the rinses. The only equipment that might be considered at all special is the Granodizer; the combination of transformer, measuring instruments, and switching gear that is manufactured specially for this process by the General Electric Co. This electrical unit is connected with the Granodizing tank through bus-bars of suitable size. The coating is deposited in about 3 min., using current densities of 35 amp. per sq. ft. of surface coated, at a voltage of from 10 volts on flat work to 30 volts on recessed surfaces. The current-density time-factor of 105 amp.-min. holds within reasonable limits, which means that the coating can be developed in more or less than 3 min., with corresponding decrease or increase in the current density.

The chemical solution used for the bath is titrated with customary laboratory apparatus or with apparatus provided by the manufacturer and adapted to manipulation by regular production employes. From the results of these titrations, additions of the proper amounts of the chemicals insure the development of a perfect coating.

Electro-Granodized surfaces when painted, lacquered, or enameled, provide nearly perfect rust prevention. The zinc-phosphate Granode coating is in itself as rust-resistant as thin coatings of electrolytically deposited zinc; but, unlike these, it is perfectly paint receptive.

This process has been developed to a state of high efficiency for coating head and tail lamps by one of the leading car manufacturers. It has been in use for nearly two years for coating electrical apparatus, where its high electrical resistance as well as its excellent rust-preventing properties have proved of great value. In general, the process is applicable to the rustproofing of surfaces when excellent rust-resistance of the painted surface is required.

In this connection an interesting test was run in the Philadelphia laboratory of the General Electric Co. Electro-Granodized steel parts coated with a glyptol finish were subjected to salt-spray test, along with similar pieces plated with a 1-mil. zinc-coating and painted with a like glyptol finish. The finish was intact and the steel did not rust on the Electro-Granodized parts that had been in salt spray three times as long as the galvanized parts, on which the paint failed, and both the zinc and the base metal had rusted. This test developed the surprising result that a Granode coating, when painted, provided better protection for steel than good electro-galvanizing when similarly painted.

Zinc Granodine

This Granode coating, despite the fact that it has the lack of ductility that characterizes all phosphate coatings, has proved unusually satisfactory for many rustproofing purposes. The Granode coating forms a perfect bond with paint. But what is most unique and of particular importance, this type of phosphate film is quite insoluble and will not rust. Therefore, Electro-Granodized products do not require immediate painting, and can be shipped or stored for several months and then can be painted without requiring any further treatment than a tack-rag wipe. This property particularly commends Electro-Granodizing to manufacturers whose products are painted to specification, but who wish to have a supply of the products always on hand and ready for immediate finishing; or to those manufacturers who would most conveniently apply the protective treatment in one plant and then paint in another.

However, there are times when usage demands an even better coating than that produced in the Electro-Granodizing process, and for such purposes the zinc Granodine treatment was developed. In this process the steel is first coated with a thin layer of zinc or cadmium in the regular plating method. Such a metallic coating has excellent rust-proofing properties and is almost perfectly ductile. Zinc and cadmium, however, themselves corrode and require protection, preferably with paint. Since paint will not adhere to these metal coatings, perfect rust prevention is not to be obtained unless the surfaces are so treated that they will form a suitable and lasting bond with the finish.

This is the purpose and the accomplishment of the zinc Granodizing process. In this treatment of the zinc and cadmium coated surfaces, a chemical is employed that is somewhat similar to that used in the Electro-Granodizing process just described. After the oil has been removed from the zinc-plated surface by the usual methods, and then the surface brushed or wiped as is necessary to produce a smoother crystalline structure than with any phosphate coating, the materials to be treated are immersed in a steel tank containing the Granodine bath. A comparatively strong solution can be used at room temperatures, while weaker solutions are effective when heated. The coating is complete in from 30 to 60 sec., and then is rinsed and dried and is ready for painting. No current is used or needed.

In this treatment the surface of the zinc is converted into zinc phosphate without materially reducing the ductility of the zinc, and without dissolving enough of it to lessen its protective effect. The phosphate coating is practically insoluble in water and in the bath, so that, while completely formed in less than a minute, it is not injured by a longer contact with the coating solution.

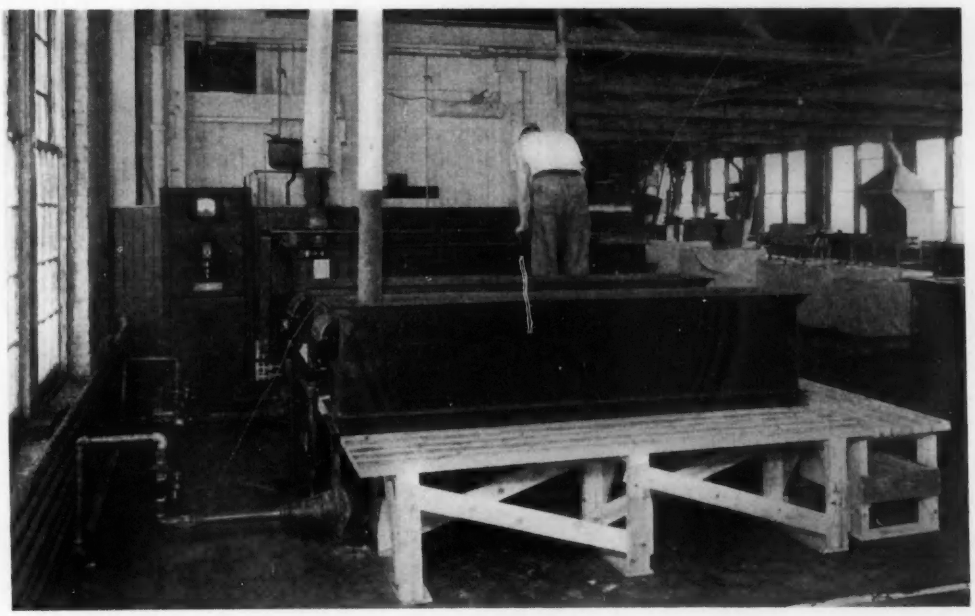


Fig. 1—Electro-Granodizing on a Production Basis

This zinc Granodizing process has been in commercial use in the automotive industry about as long as the electrolytic process, and has proved the best method for protecting steel in the light of our present standards. It is indicated for those cases where the greatest protection for the base metal is required. All materials that have been zinc or cadmium plated should be given this Granodizing treatment. The cost of Granodizing is negligible, and the resulting surface when painted provides the most nearly perfect rustproofing that has yet been developed.

A modification of the zinc Granodizing process known as Lithorizing uses the same chemical adapted to applying to large areas by spraying or brushing. This Lithoform is proving indispensable for treating large structural galvanized surfaces so that paint will adhere to them permanently.

Incidentally, let us note before leaving the zinc Granodizing process that, at the same time the General Electric Co. conducted the tests on Electro-Granodine, it ran similar tests on glyptol-painted zinc-Granodized surfaces. These tests indicated that steel plated with zinc and then Granodized was perfectly protected and held paint perfectly.

Oxalate Process

We have seen that the most perfect rustproofing is obtained by Granodizing zinc or by Electro-Granodizing steel. However, for some general-utility purposes these methods have been considered too good, or too elaborate, or too costly; so, the search for a cheaper even though not so effective process continues. In this connection oxalates and chromates have been investigated.

A process based on the use of oxalates has been proposed. In this, clean steel is immersed for from 1 to 5 min. in a heated solution of oxalic acid and iron oxalate. The grey coating that forms must soon be painted, because, without this protection, it quickly rusts.

From laboratory tests we have made, it seems that while this oxalate coating has some little effect in preventing rust spreading away from a scratch in the paint film, the brittleness of the not-too-adherent coating, and the apparent difficulty in maintaining the solution in proper condition to coat the steel consistently, seem to indicate the unsuitability of oxalates in general.

Cromodine

With the chromate treatment, however, very much more encouraging results were developed in laboratory tests, and these have been confirmed in both small and large installations of the Cromodine process in regular production. In fact, all evidence which we have on hand indicates that this method, as developed in the Cromodine process, is the most satisfactory and inexpensive treatment for rustproofing steel parts in general. In addition, the process is easily adapted to regular plant operation.

Chemically, the action of Cromodine is interesting. The treated surfaces become coated with an extremely thin film of iron chromate which is little more than a discoloration; yet it serves to polarize the nodes, and completely to stop the flow of surface currents that lead to rust.

As usual, the steel is first cleaned and the oil removed; but, unlike other treatments, careless cleaning is not so harmful, because it is not necessary that every last trace of oil and drawing compounds be cleaned away. An occasional oil spot will not prove harmful. After the cleaning operation is completed, the surface is wet for 1 min. with the Cromodine solution.

The actual Cromodizing part of the process may take place in a tank in which the steel materials to be treated are dipped in Cromodine solution, heated to 180-190 deg. fahr.; or may take place in a compartment through which the steel pieces pass on a conveyor, and are sprayed with the Cromodine solution at the same temperature as is used in the bath method. Following either the dip or the spray method of treatment, the steel surface is rinsed and dried. After it is

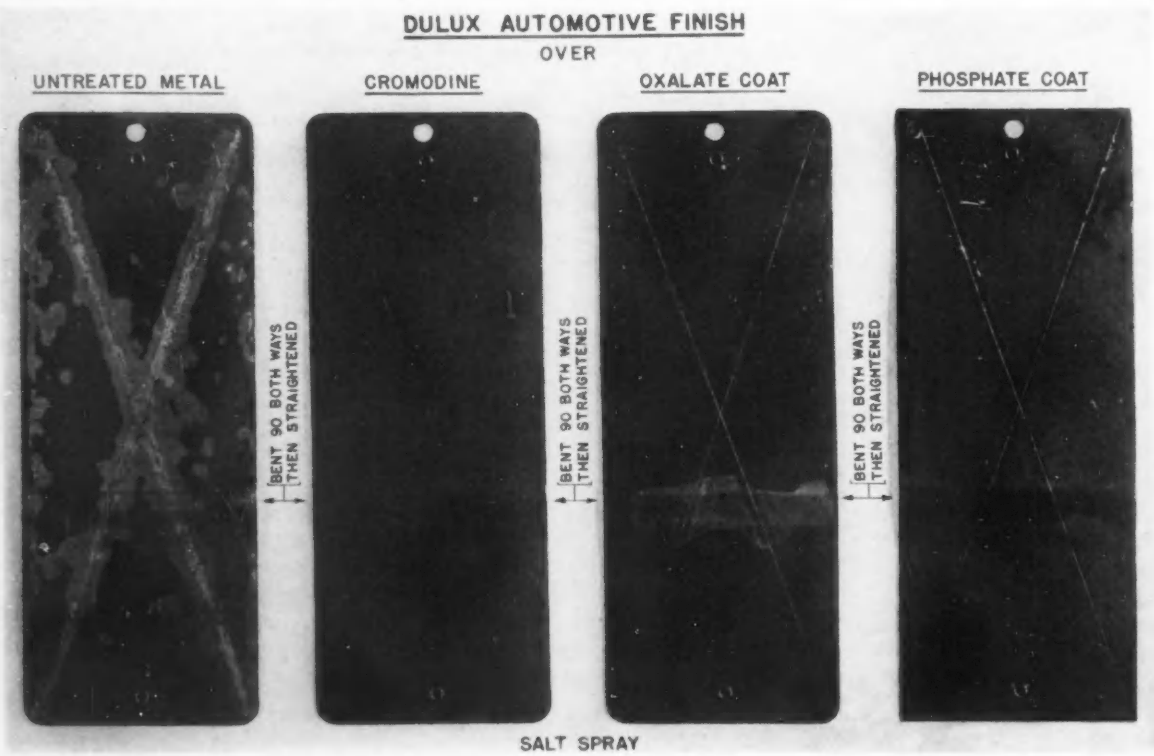


Fig. 2 — Results of Salt-Spray Test on Dulux Auto finish

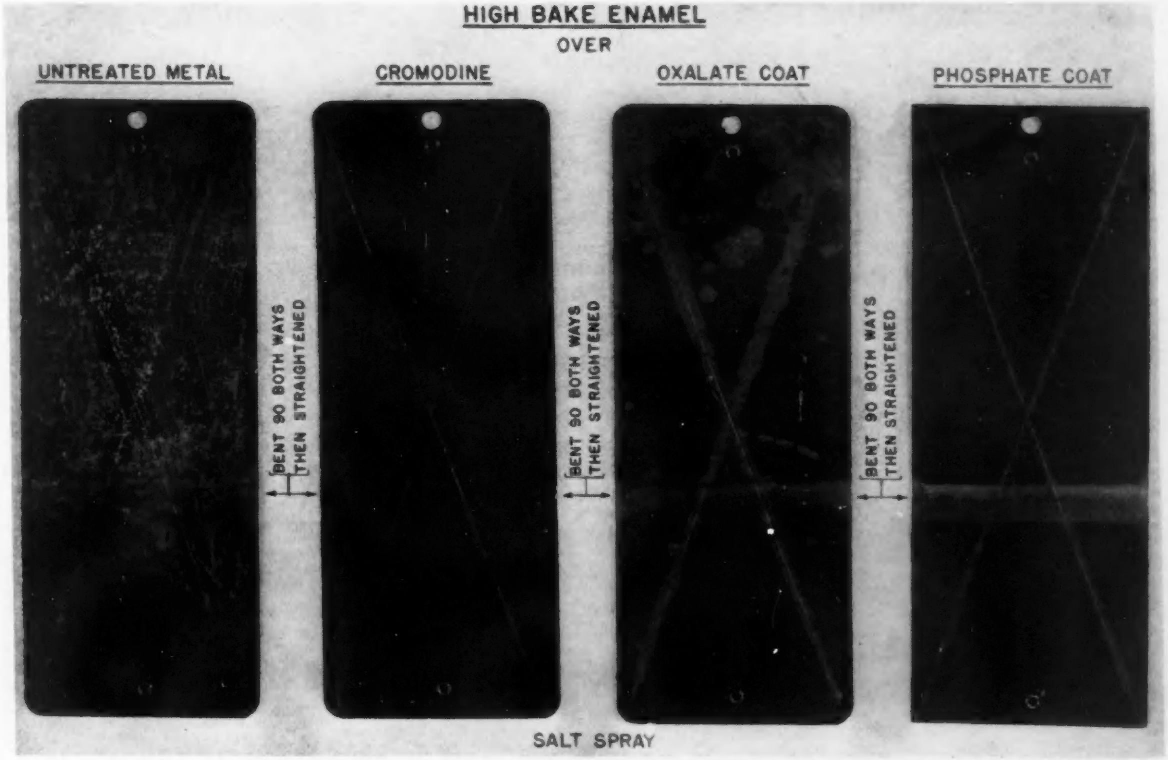


Fig. 3 — Result of Salt-Spray Test on High-Bake Enamel

dried completely, the surface is wiped with a tack rag, and then enameled or lacquered as desired.

The basic equipment necessary for the dip-Cromodine process consists of several tanks, one for the Cromodine bath, one for cold rinsing, and one for hot rinsing to dry the surface. In the spray method, either table or monorail washers can be used. While not absolutely necessary, it is desirable to use stainless steel for the tanks, the heating coils, and the spray pipes in the Cromodine compartment. Stainless steel is more durable than ordinary steel, and the slight increase in first cost resulting from its use will prove well warranted.

The Cromodine process ideally meets the two requirements that experience has indicated are necessary to general application: low cost of operation, and excellent rustproofing for steel parts that will be subjected to bending and denting after painting. In addition, Cromodizing efficiently protects the steel from the action of salt used in winter to prevent the formation of ice on the highways, an important cause of failure that has not previously been mentioned in this paper. The low cost of operation can best be realized when we understand that the cost for the treating chemical does not exceed 10 cents per 100 sq. ft. of surface treated. As to the rust-resistant properties of the Cromodized surface, let us review the results of numerous tests.

The important feature of the Cromodized surface is the flexibility of the chromate coating. Unlike other corrosion resisters, bends will not crack the Cromodized surface, or buckling will not make it chip off and cause paint failure. In short, the chromate coating applied in the Cromodine process becomes an integral part of the metal, as elastic as the metal itself. Salt-spray tests made on steel panels treated with an oxalate, a phosphate, and Cromodine, and then painted, indicated that the paint on the Cromodized surface resisted failure better than that on either of the other coatings. In truth, the Cromodized surface proved but little better than the phosphate-coated surface, until the panels were bent and then again subjected to salt spray. After bending caused the brittle phosphate to crack, the paint on the phosphate-treated panel failed rapidly. No such effect was shown after the Cromodized panel was bent and again subjected to the salt spray. Here, the paint, even at the bend, did not fail.

Fig. 2 shows test panels after having been subjected to the salt-spray test for the same length of time. Note how badly the paint has failed on the perfectly cleaned, untreated panel. Also, note the perfect condition of the paint on the Cromodized panel, even at the point where the panel was bent.

Fig. 3 shows test panels painted with High Bake Enamel, and tested in the same manner as the panels in Fig. 2. Note here again how badly the paint has failed on the panel which was merely perfectly cleaned before painting. Also, notice how badly the paint has failed at the point the oxalate and phosphate-coated panels were bent. Note too, the excellent condition of the paint on the Cromodized panel, and that, even in the area in which no bending took place, the paint on the Cromodized panel is in better condition than that on any other panel.

Results identical with those indicated in the salt-spray test were obtained in humidity-cabinet tests, and in tests in which steel panels treated with the various rust-resisters, and then painted, were exposed to the weather in Florida. In every case, with the exception of those panels which had been Cromodized, bending caused rapid paint failure, and the spread of rust around and away from the break in the paint. Similar tests in which steel panels Cromodized and painted were compared with steel panels perfectly cleaned and painted, showed that Cromodized surfaces will resist rust, both before and after bending, long after rust has developed under and in the paint on the perfectly cleaned steel.

Fig. 4 shows a close-up view of the underside of two automobile fenders, the one on the left being a regular-production fender, perfectly cleaned before painting; the one on the right, Cromodized before painting. These were processed, enam-

eled, and assembled on the same car on the same day; and then were driven under regular service conditions. Note the improvement due to Cromodine. On the untreated fender, the metal surface has been exposed and is rusting rapidly.

The excellent results the Cromodine process showed in accelerated and exposure tests of panels have been proved with fenders and sheet-metal parts on cars in regular service for nearly a year and a half in various parts of the country.

The simplicity, the speed, the low cost of Cromodizing, and the fact that this treatment seems as effective as soluble phosphate coatings for actually preventing rust under paint, commands our attention. The unusual adhesion and flexibility of paint to Cromodized metals provides a protection from the wear and tear of service that compares favorably with that of the Electro-Granodizing process, and because of its flexibility seems to approach more nearly than any other, the perfect rustproofing of Granodized zinc. These factors, in particular the low cost of the process, open the field to the treatment of countless steel products that previously have been denied corrosion protection. The Cromodine process, designed for and used with excellent results to treat cold-rolled steel to prevent rusting under paint, is surprisingly effective in accomplishing the same result on hot-rolled or forged steel, and on castings.

Summary

Thus we see that we have progressed and that we are at least delaying nature in reverting steel products to the original ore. From observations of the failures of paint—our first step in protection against rust—we have found that steel in order to hold paint must be clean; freed from rust, from oil, from mill and soldering acids, and from rinse-water alkalis. Deoxidine, a phosphoric acid-oil solvent cleaner, has solved and still solves this problem.

But this is not enough; and when we observed that moisture could get through the paint and induce the electrolytic rusting of the steel, we found we could plate other metals, notably zinc and cadmium, in thin layers over the steel; and that, while these metallic coatings would not "take" paint, they could be treated with phosphates as in the zinc Granodizing process so that paint would adhere. This zinc plating, then phosphate treating the zinc and painting, is ideal for preventing rust and paint failure. Its somewhat higher cost is well warranted when perfect protection for the metal is required.

A simpler method for this plating process was developed in which the steel could be plated directly with a zinc-phosphate coating. This is the Electro-Granodizing process. The coating produced, rust-resistant itself, provides one of the best foundations for finish coats. Then also, we found that phosphate coatings could be applied directly to steel, without an electric current. Such a method is the Bonderite process. All these methods have been effective in increasing the life of the paint finish by decreasing the tendency of the steel to rust, or by improving the bond of the finish to the metal; but the phosphate coatings have the disadvantage of breaking when bent or distorted.

So the search for an inexpensive coating that would not break led to Cromodine, a chromate coating easily applied, and which, when once applied, becomes an integral part of the steel itself, and is as ductile and as elastic as the steel base. For steel that will be subjected to rough treatment, this Cromodine process has proved superior in effect to the phosphate coatings. It is being adopted by manufacturers of different types of steel products where it is necessary to provide efficient rustproofing at low cost.

The outlook, then, in the struggle to duplicate the famous one-horse shay by extending the lives of those parts that are most quickly destroyed by corrosion, is distinctly encouraging. Indeed, we may say that by application to our needs of the processes now available, the rough trip from the assembly line to the junk yard may be made appreciably longer and definitely more beautiful.

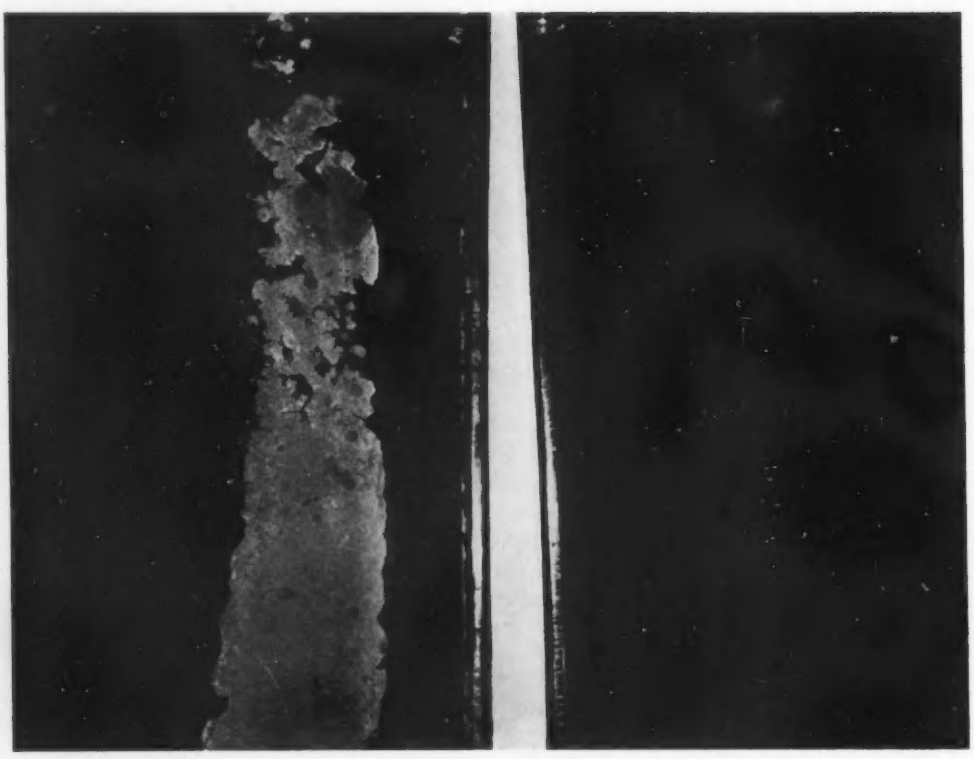


Fig. 4—Results of Service Tests on Automobile Fenders

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Laws, Transportation and Maintenance Debated at Newark Meeting

POINTING out how inefficiently and excessively heavy much of the railroad equipment actually is by comparison, Federal Coordinator of Transportation Joseph B. Eastman, in one of the many important talks which featured the Regional Transportation and Maintenance Meeting at Newark, Oct. 29 to Nov. 1, intimated that S.A.E. members may well be called on to assist railroads in adapting numerous new automotive types of equipment to railway needs.

Major Roy F. Britton, National Highway Users Conference, declared that the motor carrier industry, so far as legislation and regulation are concerned, "must have a suit of its own and not a hand-me-down from the railroads."

Held through the joint efforts of the Metropolitan Section, Society of Automotive Engineers, and the New Jersey Motor Truck Association, with the cooperation of the Highway Users Conference and the Newark Chamber of Commerce, the meeting was one of the most successful of its kind ever staged. Nearly 1000 members and guests participated.

Among the many other interesting highlights developed during the seven sessions in which more or less formal papers and discussion were presented, were included:

(1) A statement by James J. Shanley, chief inspector, New Jersey Motor Vehicle Department, that States having compulsory inspection of motor-vehicles cannot point to any reduction in accidents attributable thereto and one by J. F. Winchester, chairman, Metropolitan Section, that the S.A.E. being an engineering Society probably should confine itself to acting in an impartial advisory capacity on the technical phases of inspection problems, leaving other organizations which may desire to do so to sponsor inspection and other related work of a public nature;

(2) Emphasis by experienced operators on the idea that repairing should be the last resort of maintenance, preventive methods being of major importance;

(3) Mention by Clinton Brettell, in charge of R. H. Macy's fleet, of the desirability of truck manufacturers sticking as closely as possible to standard dimensions and standard location of units in their design work;

(4) Advice to truck carriers from H. S. Shertz, American Trucking Association, that, in border line cases to which the new Motor Carrier Act may or may not apply, they should file under the grandfather clause and reserve their rights pending later clarifying rulings.

Scores of other significant points were brought out both in papers and discussion, the presentations of O. M. Brede, S. Ward Widney, T. R. Kelley and Austin Wolf attracting special interest from a strictly engineering viewpoint.

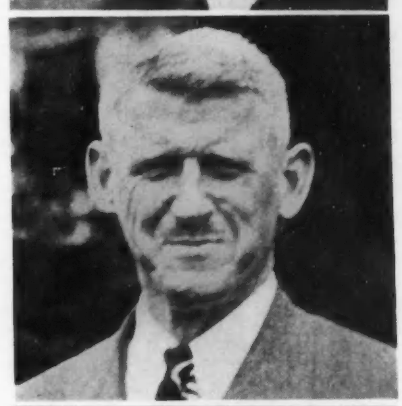
Staged simultaneously with the meeting was an equally successful truck show which was generally hailed as a marked improvement over the excellent one put on during a corresponding meeting a year ago.

Particular credit for development and running of this remarkably successful transportation and maintenance gathering is due to J. F. Winchester, Metropolitan Section chairman, and president, New Jersey Motor Truck Association; Capt. George Gray, chairman of the program committee and of the Metropolitan Section T. & M. Activity; Walter Peper,

Staged Successful Sessions

John F. Winchester
Directed Activities as General Chairman

T. C. Smith
Cooperated as Vice-President of Society for T. & M.



Capt. George E. Gray
Headed Program Committee

Walter S. Peper
Was Vice-Chairman of Program Committee

vice-chairman of the Program Committee; T. C. Smith, vice-president of the Society representing Transportation and Maintenance, and to numerous other Section officers and committee members who cooperated to make the meeting a success.

Mr. Winchester presided at the dinner and introduced the toastmaster, W. Paul Stillman, president of the Newark Chamber of Commerce, who in turn introduced the principal speakers, Joseph B. Eastman, Federal Coordinator of Transportation, and Roy F. Britton, director, National Highway Users Conference. Gov. Harold G. Hoffman of New Jersey was scheduled to speak but was unable to be present.

Mr. Eastman spoke highly of the motor transportation industry, indicated that it is very definitely here to stay, and said that the new Motor Carrier Act specifically provided for its continuation. He also indicated that motor transportation in some respects is a distinct asset to the railroads despite the attitude which they have taken. In addition he said that great care had been exercised in selecting the personnel of the Motor Carrier Bureau, which will have a hand in administering the act, so as to be sure it is not"railroad-minded", as some have feared it would be. On the contrary, Mr. Eastman said, those selected to date and those still to be chosen are men of experience and training in automotive transportation and are of such standing as to command the full respect of the motor transport industry.

In respect to the railroads themselves, Mr. Eastman said that the Interstate Commerce Commission has pointed out the inefficiency and excessive weight of their equipment. In consequence, many of them are turning to automotive types of equipment or are becoming interested in such equipment as a means of solving some of their transportation problems. The speaker intimated that such developments should be of special significance to S.A.E. members.

Mr. Eastman spoke in appreciative terms of his contacts with President Stout, and said he was impressed by the latter's statement that equipment which is new today will be outmoded and considered inefficient or obsolete five years hence. The speaker indicated that railways require not only lighter and more efficient equipment, but more flexible units adaptable to various classes of service. To this end, consideration is being given to units which can be operated separately or in trains. The Diesel engine with various types of mechanical and hydraulic drives is getting considerable attention for applications in railway use, as is much other equipment which is unconventional from a railway angle.

In conclusion, Mr. Eastman declared that there is ground for optimism from an automotive transportation point of view and left his hearers with the impression that there is little occasion for apprehension in respect to the application of the Motor Carrier Act.

The remarks of Major Roy F. Britton tended to confirm this impression, as he spoke favorably not only of Mr. Eastman himself but of his "sound and statesmanlike pronouncements" in declaring that the motor carrier industry must not be given "a suit of regulatory clothes which does not fit" it; but that "it must have a suit of its own, nicely made to measure, and not a hand-me-down from the railroads."

On the other hand, Major Britton said that, quite aside from the regulations recently imposed by Congress, highway transportation is already over-regulated and over-taxed, and cited many state enactments to substantiate this fact. There, is, however, great hope of correcting this situation through the new Federal law, except, of course, in the matter of taxes. Major Britton also pointed out that the matter of rates for motor transportation, which must be filed under the new law, is beset with many difficulties. In conclusion, referring especially to present high motor-vehicle taxes in New Jersey, he said that vehicle owners should present a solid front against further increase in this load and should insist that every cent collected should go into highway building and maintenance.

Motor Carrier Act Session

Robert Jackson, vice-president, N.J.M.T.A., acted as chairman of the session devoted to a round-table discussion of the new Motor Carrier Act and introduced Harold S. Shertz, associate counsel, American Trucking Association, who explained certain provisions of the act and answered a great number of questions as to what carriers come under the act and how those who do should proceed in securing such licenses or certificates as are required of all motor carriers engaged in interstate commerce. The discussion developed that there are probably many so-called "borderline" cases to which the new law may or may not apply.

Service Session

Some two hundred members and guests attended the session on service problems and heard two excellent papers. The first by O. M. Brede, dealt largely with preventive maintenance and included many graphic illustrations showing clearly that such maintenance not only pays handsomely in reduced operating costs but is also an important factor in reducing accidents. In the second paper Clinton Brettell gave an outline of the service methods and policy followed in maintaining the fleet of trucks operated by R. H. Macy & Co.

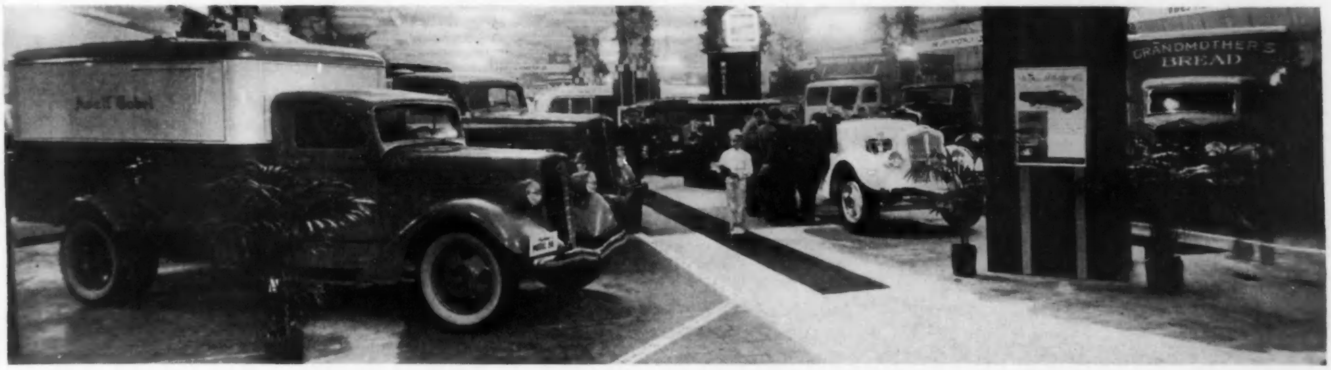
Mr. Brede's paper dealt largely with a system of preventive maintenance. In it he pointed out that a mere system of cost accounting, although it gives costs, is far from being all that is required. It is necessary to ask, "What caused this cost?" Out-of-service time may even cost as much as the entire maintenance bill. The author stated that if all personnel connected with fleet operation could be impressed with the fact that repairing is the very last resort of maintenance and that every other means should be utilized before resorting to it, and further that the efficiency of maintenance of a fleet is inversely proportional to the amount of repairing undertaken, great strides would be made in the development of fleet maintenance. Repairing becomes inevitable in time but should be postponed to the furthest possible date, the aim and objective of maintenance being primarily to prevent repairs.

To demonstrate the truth of this conclusion, the author displayed several charts and record sheets used in a logical preventive maintenance system. In one chart tracing the cost per mile of maintenance over a period of 20 months, it was shown that this cost has risen steadily to over 4 cents per mile after 8 months. Preventive maintenance was then applied and within about a year the cost had been reduced to only a little over two cents per mile.

Having clearly demonstrated the value of preventive maintenance, Mr. Brede proceeded to show in some detail what is involved in such maintenance.

Clinton Brettell in his description of the methods and equipment used for maintenance and repair of vehicles in the Macy fleet indicated that, in the case of some units, spares are provided so that when similar units are giving trouble in service they can be replaced temporarily by the spare while the original unit is put into proper condition during the day without taking the truck out of service. A regular system of preventive maintenance is followed, however. The shops are

Interest Was Great in the Truck Show Held Simultaneously with the Meeting



well equipped for most of the work required, but it is found to be less expensive to have certain classes of work, such as welding, for example, done by specialists outside the Macy shops. The latter have facilities for body maintenance, including refinishing. In repainting, the old finish is usually removed from metal by sand-blasting and from wood by burning, as these operations tend to prevent chipping of the new finish.

In concluding his paper, Mr. Brettell recommended that truck manufacturers adhere so far as possible to standard dimensions and locations of units, and make as few changes as possible in units that are known to be giving satisfactory service. A better grade of accessories, including shock-absorbers would be desirable, he said.

T. L. Preble was the principal discusser and commended both authors on the excellence of their papers. He mentioned the need for considering out-of-service costs in figuring the total cost of repairs, and said that the cost of carrying on-hand units for replacement should not be overlooked. It is quite possible to over-tool for maintenance and repair work, especially in cities where the services of specialists in certain lines in which a given fleet cannot keep tools busy are available at moderate cost.

Although vehicle manufacturers understand the need for service, Mr. Preble indicated, they do not in many cases understand the service man's problems or benefit by his experience in correcting faults which could be overcome if designers had better contacts in the service end. It is important, he said, in supporting a statement of Mr. Brettell, that vehicle manufacturers hold to a standard construction so far as feasible and make a minimum of changes in design where the equipment is performing successfully. When changes are made, the fleet operator should be kept fully informed as to their nature.

Herbert Chase indicated that spring maintenance and service work is often neglected and that trucks especially are often equipped with springs which do not fit the class of work for which the particular truck is used. When proper springs are fitted and given proper care, other service costs are likely to be lowered considerably, as then the chassis is properly cushioned against damaging shocks.

Inspection Session

James J. Shanley, chief inspector, Motor Vehicle Department, State of New Jersey, was the principal speaker at the Thursday morning session dealing with vehicle inspection. He pointed out that adequate maintenance pays dividends not only in lessened depreciation but in freedom from the penalties that often attend the use of unsafe vehicles. Unfortunately, he said, although the wise operator provides for regular inspection and proper maintenance, this class of user is in a minority. The majority provide only enough maintenance to get by. Nevertheless, states having compulsory inspection cannot point to any reduction in accidents attributable thereto. This is probably because only the small percentage of accidents are caused by faulty vehicles.

Inspector Shanley said that he held no brief either for or against inspections required by law, but pointed out many of the difficulties which different types of inspection involve, including the troubles incident to securing proper personnel. State inspections are commonly required only twice a year, he said, but proper maintenance requires much more frequent inspection. No campaign against accidents can in any case get very far, he indicated, by concentrating on any one cause. It is necessary to hammer away at all causes. Any campaign for inspection, if it is to be successful, must be backed by a preponderance of public opinion and must be set up with the best technical practice to command respect and to avoid undesirable features. Those who are pioneering in this field cannot be too highly commended for pointing the way.

T. C. Smith, who acted as chairman of the safety session, also participated in the discussion. He stated that if, as some figures indicate, only six per cent of accidents result from defective vehicles, a great deal would still be accomplished if this figure could be cut to say three per cent. He said that where enabling acts for inspection are put into effect, they should delegate to the enforcement group authority to determine the inspection details and practices to be followed in order to keep the inspection requirements flexible as regards changes from time to time. He mentioned the work being done by S.A.E. committees on the engineering side of the problem and said that the divergence of views on what constitutes adequate safety in respect to such items as steering, for example, makes it very difficult to formulate satisfactory specifications.

J. F. Winchester said that the S.A.E., being an engineering society, should probably confine itself to acting in an impartial advisory capacity on the technical phases of inspection problems, leaving other organizations which may so desire to sponsor inspection and other related work of a public nature. Business itself, being directly concerned, may be in the best position to do a good job in the interests of safety. He felt, he said, that the industry should place less stress on speed in its advertising, as otherwise adverse legislation is likely to be encouraged.

One speaker said that there must be some maximum speed above which the average motorist cannot drive with safety

and that if this speed were known, safety would be promoted if cars were so made that they could not exceed it. He added that although data collected within his own organization showed only 5 to 6 per cent of accidents caused by defective vehicles, those known to have been so caused are usually very expensive. In some instances where state inspection has been required, it was found that company inspection had been neglected, with the result that accidents increased until the cause was discovered and remedied.

Capt. George Gray raised the question of adequacy of hand brakes and said that some requirements are to the effect that they must be capable of holding the vehicle on the maximum grade it can climb. He asked how measurements in this regard could be made. Other discussers indicated that troubles had been encountered with provisions of this nature, but that they might be resolved into measurements of stopping distance when applying only the hand brake. Clinton Brettell indicated that hand brakes which may meet the requirements when tested are not likely to do so long because of the rapid wear which is brought about as a result of comparatively few quick stops.

B. J. Lemon, among others, discussed the matter of tire wear as affecting safety and said that opinions differ greatly as to when a tire becomes unsafe. Thus, a four-ply tire with two plies worn through might be very unsafe whereas a fourteen-ply truck tire with two plies worn through might still be safe. No very definite conclusions have been reached by the S.A.E. committee considering this matter, said Mr. Lemon, beyond a belief that inspectors should be lenient and their authority confined to warnings of danger.

Diesel Power Session

Friday afternoon's session, devoted to Diesel power, was one of the best attended technical sessions of the meeting. Dr. A. E. Becker acted as chairman and introduced the speaker, T. R. Kelley, Diesel field engineer of Waukesha Motor Co. Mr. Kelley's paper consisted quite largely of a description of the Waukesha Comet Diesel engine and of the facilities for its production and testing. The author stated that the engine was based on a development by Harry R. Ricardo of England.

The paper dealt also with factors relating to the successful operation of Comet Diesel engines in trucks and with the performance of many trucks in actual service using this engine. He stated that the success of a Diesel engine depends quite largely upon the operator and his willingness, in the beginning, to become thoroughly acquainted with the engine and its adjustment and maintenance. The paper states that, in the experience of the London General Omnibus Co., road failures occur in buses powered by gasoline engines in approximately each 200,000 miles whereas with the same vehicles powered with Diesel engines the average is 400,000 miles before road failures occur. Diesel engines will continue to operate, the author states, even though injectors may not be atomizing properly and the lubricating oil may be sludging badly, but if these conditions are allowed to continue, they result in stuck piston rings, crankcase oil dilution, excessive cylinder wear, sticking valves and possibly scored cylinders. Hence, it is essential that frequent inspections be made to insure best economy; but when substantial fuel savings are effected by the Diesel engine, it is not prohibitive for the operator to invest part of the savings in inspection and adjustment, which are much more effective than the usual inspection system employed with gasoline engines.

The author stated that the Diesel engine will not run well on crude oil or bunker oil, but will run well on fuel of the following specifications:

Viscosity, Saybolt at 100 deg. F., (38 deg. C.)	35 sec. minimum
	80 sec. maximum
Cold test	0 deg. F.(−18 deg.C.)
Sulphur	0.7 per cent maximum
Water and sediment	0.5 per cent maximum
Residue: gum, carbon ash, etc., after 100 grams have been ignited and burned out in an open dish	2.0 per cent maximum by weight
Cetane No. (for Diesel engines only)	50 minimum

These specifications are met by most No. 2 and No. 3 furnace oils throughout the country.

Many lubricating oils on the market cause serious piston ring and valve sticking, but some satisfactory oils are available. Satisfactory lubricating oil specifications are not available at this time, but are being formulated by an S.A.E. research subcommittee. It was made clear that good oil filters should be used and that they should be cleaned frequently.

Maximum economy and best performance are obtained with water jacket temperature between 170 and 195 deg. fahr., to maintain which an accurate thermostat is required and sometimes a radiator shutter to avoid excessive cooling in descending long grades in cold weather.

Best performance is secured when the conditions are such that the engine speed never falls below 1000 r.p.m., as bearing pressure may be excessive at lower speeds.

The author said that his company does not consider it advisable to sell replacement engines directly to operators without supervision or instructions. He made it clear that Diesel engines are not justified on trucks which run less than 50,000 miles a year or which run less than 250 miles a day average when in use. When mileage is less than this and better economy in fuel is required than is given by gasoline engines, the Hesselman type of engine, which costs 30 to 40 per cent less than the Diesel, gives excellent results.

The author quoted the results of tests of several heavy trucks, in which the average miles per gallon of fuel with the Waukesha Diesel engine was 7.78. The average ton miles per gallon was 182, the maximum 278, and lowest 151.

The meeting was followed by a lively discussion, which was started by the chairman, who remarked that he was glad that the author had made it clear that Diesel engines would not operate satisfactorily on any kind of fuel.

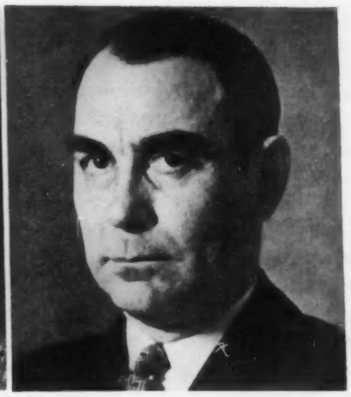
In response to a question by T. C. Smith regarding gear changing, Mr. Kelley stated that in one test using two trucks of the same make, and with all conditions comparable except as to engines, the truck with the Diesel engine required 22 per cent fewer gear changes in traveling the same course at the same average speed than did the truck with the gasoline engine.

O. F. Allen said that experience of the London General Omnibus Co. has shown the same general performance in respect to meeting schedules with gasoline and Diesel-engine buses having other conditions the same. Now, however, the Diesel has been decreased in weight which is more nearly comparable to that of the gasoline type. As the Diesel has better torque characteristics, however, it is believed that schedules can be improved by its use, provided a proper form of transmission is employed. In this country, much depends on relative fuel costs including the tax on the fuel as to what the economics of the Diesel will be.

A Speaker and Two Session Chairmen

Austin M. Wolf
Analyzed New Automobiles

Martin Schreiber
Presided at Service Session



Dr. A. E. Becker
Was Chairman at Diesel Meeting

In commenting on the use of Diesel-engine trucks by his company, Captain Gray said that injection nozzles are inspected each 12,000 miles. The trucks operate without a bad odor as long as the nozzles are properly adjusted. In response to a question by F. H. Dutcher, Mr. Kelley said that a Hesselman engine justifies its use in trucks which average from 100 to 150 miles a day, and, being less expensive than Diesel engines, pays for itself more quickly.

When asked about his experience with Diesel engines in buses, A. A. Lyman said that it was obtained with German engines some six or seven years ago, when American-built Diesels of the desired type were not available. Some trouble was encountered with the aluminum pistons used, but the engines were fairly satisfactory and seldom smoked, even though various grades of fuel were used.

Several questions were asked concerning the replacement of gasoline engines by Diesel engines and the relative torque of each, some contending that the Diesel and some that gasoline engines develop the higher torque and some that replacements can be made with satisfaction and others that such replacements lead to trouble. Mr. Kelley indicated that his company does not advocate replacements believing that it is better to start with new rather than with old equipment. It recommends Diesels only where suitable servicing can be assured and other conditions are favorable. One discusser said that trouble is likely to result, as it has in some cases, because the Diesel used for replacement often has a larger displacement than the engine replaced has. Mr. Horine questioned whether anyone holds the correct general answer, partly because of the variety of conditions involved. He indicated that the Diesel has advantages as a fuel saver and nothing else: that it does not give corresponding results in all respects when substituted for the gasoline engine. In meetings, the latest type of engine is likely to be discussed, he added. In the field, Diesels do smoke and do produce a foul smell. On the coast, the exhaust is usually through a stack for this reason.

Spring Testing Session

Much interest centered in the Thursday evening session devoted largely to S. Ward Widney's timely paper entitled "Spring, Tire and Shock Absorber Testing Developments," although the attendance fell short of that at some other sessions. Capt. George Gray presided. Dr. Glenn Havens, scheduled as the chief discusser, complimented the author on the work outlined in his paper, but for the most part dealt with certain fundamental problems of riding comfort and tire testing which were not given extended consideration in the Widney paper. The latter, previously published in abstract form in the Metropolitan Section *Accelerator,* dealt very largely with an instrument called the Ride-O-Graph, developed by the author, and its practical use in testing suspension systems in the laboratory and service shops of the B. & J. Auto Spring Co. This instrument draws time-displacement curves of the wheels and body of any vehicle when these are subjected to displacements such as occur when the wheel drops a given distance.

In the paper, the author showed several curves of this character and explained how they are used in determining certain of the riding characteristics of the vehicle tested. He made it clear that the graphs can be and are analyzed to determine the accelerations and forces which bodies and axles are subjected to and that, from the results thus obtained, the springs, shock absorbers and tires can, if required, be intelligently modified to improve riding properties. Such alterations, the author indicated, not only improve riding, but tend to increase safety by keeping tires in contact with the road. In addition, they frequently have a marked effect in reducing maintenance costs of the entire vehicle by reducing the shocks to which it is subjected.

It appeared from the paper that the Ride-O-Graph is not only useful to those who design and test springs, shock absorbers and tires, but can be made of great value to vehicle operators by first determining whether the suspension units are in satisfactory condition and thereafter checking them to see that they are properly maintained.

In his discussion, Doctor Havens said that he agreed with the author that the problem of shock absorption is not one of statics but of dynamics; that the combined action of the tire, spring and shock absorber should be studied together and that it is not sufficient to study each separately. He said, however, that any thorough study of riding comfort must take into consideration both physical and psychological phases of the subject. He cited data indicating that comfort depends on the product of the amplitude and the cube of the frequency of the motion. The shock resulting from running over a bump the dimensions of which are small compared with the dimensions of the wheel varies as the width of the bump and as the inflation pressure of the tire and inversely as the square of the velocity. The damping of vibration by the tire increases with decreasing speed, with decreasing inflation and with increasing deflection. The tire manufacturer can soften the ride by changing the angle of the cord, the width and the profile of the tread; by changing the size of unit design and by changing the cross-section of the tire. Various graphs in support of these conclusions were presented.

A written discussion of the Widney paper, prepared by

Roy W. Brown, was read by Walter S. Peper. In this Mr. Brown commended efforts of the author to bring into the service field equipment to measure spring and shock absorber performance, which he said will concentrate attention on the major difficulties encountered in suspensions. This in turn will result in developments tending to eliminate difficulties, as exemplified by the remarkable progress made on passenger-car suspensions in the last two years. The use of time-displacement curves is not new, said Mr. Brown, but the double differentiation of such curves to obtain acceleration rate is not sufficiently precise for practical usage. The taking of drop tests, such as the author uses, can be considered only as an initial effort in approximating dynamic conditions on the road where such factors as interaction between springs, steering, driving and braking torques, gyroscopic reactions and natural frequencies of numerous parts occur simultaneously to make up the complex phenomena known as a "ride." It is probable that acceptance of "soft" suspensions, minus cornering instability, will write a new chapter in motor car suspension, and thereby relieve the "ride" engineer of further consideration of such factors as interleaf friction so prominent in previous discussions.

In response to Mr. Brown's discussion, Mr. Widney said that it is not enough in service fields to know the comfort status of a vehicle. In commercial vehicles it is important to know the safety, maintenance and depreciation status, and the cause and extent of deficiencies in the effectiveness of any of the three elements of the suspension system must be determined. The Ride-O-Graph makes this possible. As to measurements of acceleration from curves drawn by this instrument, the method used is sufficiently accurate for practical service work. Steering, driving and braking torque enter into the "ride" problem remotely; not directly. Interaction between springs and gyroscopic reactions can be indicated definitely by the Ride-O-Graph. Just how the interleaf friction of springs can be disregarded as long as leaf springs are used, as they are on many "soft" suspensions, is not clear. The objective in the test methods outlined in the paper, Mr. Widney added, is to determine the essential facts concerning the motions involved in the suspension system with a minimum of time and effort. Thus far, in service work, no means other than the Ride-O-Graph has appeared to give this important information. When some better means becomes available, the author will be the first to recommend its use, he said.

In response to the question about spring lubrication, Mr. Widney stated that it is difficult to say just how much lubricant is desirable although some lubrication is needed. The use of ground leaves is also desirable.

O. M. Brede
Championed Preventive Maintenance

W. Ward Widney
Told of Testing Ride Characteristics

T. R. Kelley
Described Diesel Developments

Passenger-Car Session

New things in passenger-car design and construction furnished the theme for the "Preview of 1936 Cars at the Automobile Show" which took place on the concluding evening of the meeting. Austin M. Wolf presented the paper entitled "Refinements and Super-Styling in the 1936 Models," which appeared in the November S.A.E. JOURNAL, but at the meeting itself many more views of new cars and parts thereof than could be used in the JOURNAL story were presented. Herbert Chase, who acted as chairman of the meeting, made numerous comments about various points raised in the paper and discussion and also indulged in some of his "pertinent pokes" such as have been heard at many Society meetings.

E. S. Hall, when asked to give his comments about the 1936 models, said that he believes they are characterized by too much "tin ware." He added that he thinks there is need for a smaller car than any of those described; one which would be capable of averaging around 30 miles per gallon of fuel in normal use.

Asked by B. J. Lemon about the use of 15-in. wheels, Mr. Wolf said he believes they are confined to only one model. Merrill C. Horine said that, although several cars are supposed to have "independent" suspensions, some of them now include anti-sway bars in front, which, since they produce reactions at one wheel when the other is raised or lowered, no longer are truly independent. He also commented on the practical elimination of free wheeling and on what he considers a reduction in the emphasis on streamlining. The chairman pointed out, however, that his own observations in the latter respect indicate that there is more rather than less tendency toward streamlining and mentioned the new Cord as an example of a car in which practically all protuberances had been eliminated in the interest of streamlining.

Mr. Wolf commented on the new Lincoln-Zephyr and Cord as instituting a big change in the attitude of body designers and producers toward the use of bodies which require no separate frame. He added that he believes the trend toward this type of construction will continue. He also indicated that there probably is a demand for a light car such as Mr. Hall mentioned, and commented on the use of more nearly "square" engines, with short stroke as increasing and being desirable because of lower piston speed. He agreed that free wheeling is practically out, but said that overdrives have shown a noteworthy increase. There are also some cars with engines too large for proper economy, he said, and some so

(Continued on page 21)

The Electrolytic Cleaning of Exhaust Valves

By S. D. Heron, George Calingaert and F. J. Dykstra
Research Laboratories, Ethyl Gasoline Corp.

IT is often desired to remove completely the deposits, such as engine carbon, scale and lead compounds, and the like, which are found on exhaust valves, without removing any of the underlying metal. Similarly, in the case of scaling test-specimens, forgings, and so on, it is often desired to clean the surface down to the metal before inspection.

An article[1] by U. C. Tainton, entitled "A New Process for the Cleaning of Metals," applies particularly to the de-scaling of wire prior to drawing operations. This process consists in using the metal to be cleaned as the cathode in a bath of fused sodium hydroxide-sodium carbonate. The applicability of this method to the cleaning of exhaust valves was investigated, and, after several variations had been tried out, a procedure was finally adopted which appears to be practical and efficient. The equipment and method used in this laboratory are described here.

Procedure

(*A*) *Description of the Equipment.*—The necessary equipment comprises essentially a heated electrolytic bath, a 6-volt storage-battery, suitable leads with clamps and an ammeter. The set-up used in this laboratory for the cleaning of valves is illustrated in Figs. 1 and 2. In Fig. 2, a switch has been added which permits reversal of the current, as will be explained. Additional equipment comprises a Transite shield to prevent spattering when the valve is lowered into the electrolyte, a stirring rod, metal prongs, a brass-wire brush, and a "spacer". The latter is a section of 3-in. steel-tubing ½ in. shorter than the depth of the bath. On account of the danger of handling molten alkali, it is important to provide a laboratory coat with sleeves, canvas gloves with gauntlets, and goggles, as worn by the operator shown in Fig. 1.

(*B*) *Preparation of the Bath.*—The electrolyte is first prepared by putting into the melting pot 600 grams of caustic soda and 200 grams of sodium carbonate. With the lid on the pot, this mixture is heated until it is melted. Traces of moisture in the materials may cause the melt to froth at first. If this occurs, the heating process is slowed down until the frothing subsides. When the level of the material is lowered by melting, an additional 200 grams of sodium carbonate is added in one or more portions and the process repeated. The composition of the melt is thus 60:40 caustic soda—sodium carbonate. Appreciable deviations from these proportions have little if any effect on the cleaning process.

(*C*) *Preparation of the Valve.*—Any excess of oily material which might react violently with the molten alkali is first removed from the valve, either by heating in a flame or by washing with kerosene or gasoline. The spacer serves to set the depth of immersion of the valve so that it comes approximately ½ in. from the bottom of the pot. This is done by standing the valve in the middle of the spacer, slipping the transite shield over the stem until it rests on the spacer, and fastening the spring-clamp connection flush against the shield.

(*D*) *The Cleaning Process.*—When the bath is up to temperature, which is indicated by the fact that the melt is fluid and no longer froths or boils, the lid is removed. The operator holds the valve by the tip of the stem by means of the prongs, and lowers the valve and shield assembly onto the bath, as shown in Fig. 1. The shield practically covers the bath before the valve touches the melt, thereby minimizing the danger of spattering.

The resistance of the system is preferably adjusted so that the ammeter indicates approximately a 6-amp. discharge with

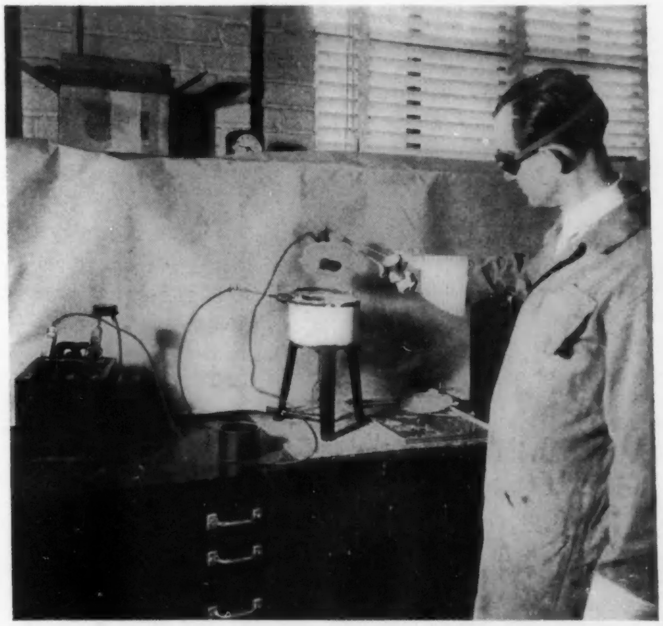


Fig. 1—Illustrating the Cleaning of Exhaust Valves by Electrolysis of Fused Alkali
The operator is ready to place the valve to be cleaned (the cathode) in the molten electrolyte.

[This article was approved and sponsored by the C.F.R. Aviation Gasoline Detonation Subcommittee.]

[1] See *Wire and Wire Products,* vol. 9, 1934, p. 399.

valves from 1¼ to 3 in. in diameter. Depending on the thickness of the deposit, and also on the shape of the valve, the electrolysis is continued for 2 to 5 min. The valve assembly is then removed from the bath, this time by grasping the edge of the shield instead of the valve stem. This assembly is removed, the lead and shield are removed and the valve is immersed in water. After the solidified caustic has been dissolved off, the remaining thin film is brushed off by means of the brass-wire brush.

The valve should now have a clean metallic appearance. If the deposit has not been completely removed, particularly in some inaccessible places, the operation may be repeated.

Notes

(1) Technical grade caustic soda may be used, in powder, flakes or any other convenient form. The sodium carbonate should be anhydrous.

(2) No definite information is available regarding the number of valves which can be cleaned before renewing the melt. As many as 30 valves have been cleaned easily with one melt, but this number will no doubt vary with the type of valve and deposit.

(3) The solidified electrolyte will absorb moisture from the atmosphere and frothing may, therefore, be experienced when the bath is heated up again after standing. If a large amount of liquid collects on top of the melt it may be well to pour this off, adding up caustic soda and sodium carbonate approximately in the ratio of 60:40 if necessary to bring the level of the molten electrolyte up to about 1 in. from the top of the pot. Storing of the cooled melting pot in an airtight container, such as a laboratory desiccator, will obviate this trouble.

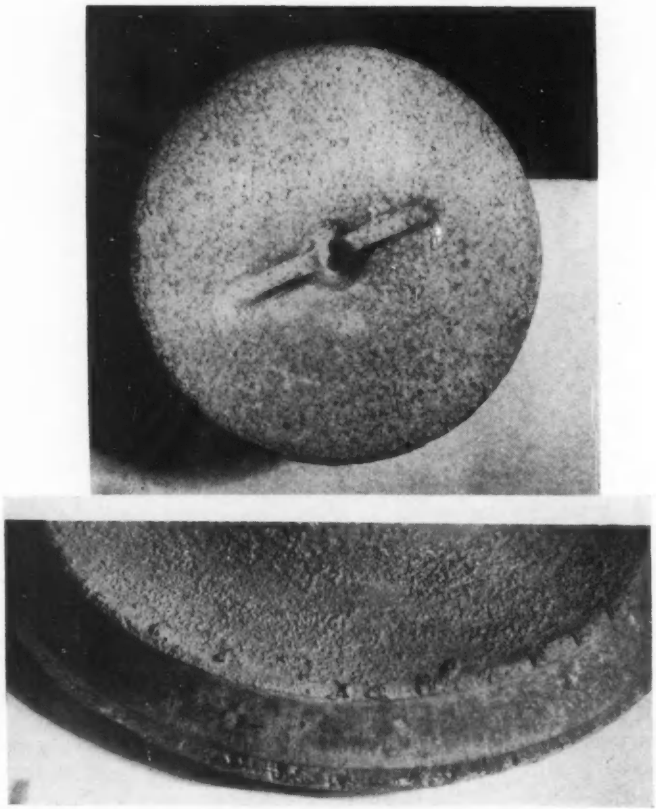


Fig. 3—Exhaust Valve, Enlarged, Showing the Deposit on the Seat and on the Head

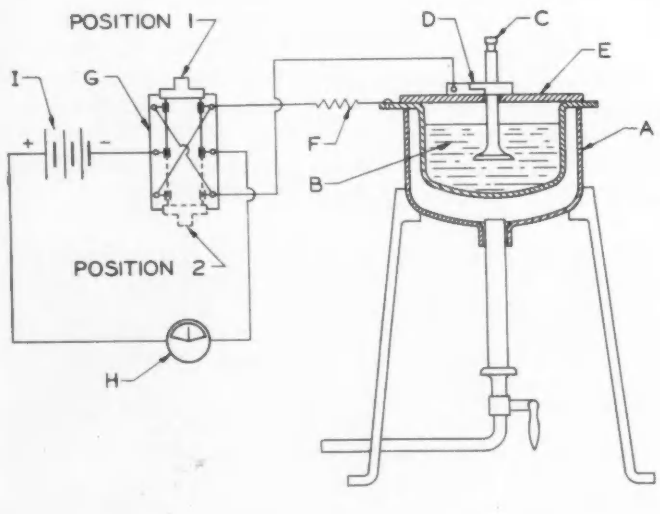


Fig. 2—Diagram of the Equipment

A—Melting Pot with Burner, 5¼-in. diameter, 3 in. deep (No. 15 melting-pot furnace, Johnson Gas Appliance Co., Cedar Rapids, Ia., fitted with a home-made lid).

B—Molten Electrolyte (60 weight-per cent of sodium hydroxide and 40 weight-per cent of sodium carbonate).

C—Valve To Be Cleaned.

D—Clamp.

E—"Transite" Cover.

F—Resistance (0.5 ohm).

G—Two-Pole Double-Throw Knife-Switch.

H—Ammeter (0-30 amp., direct current, charge and discharge).

I—6-Volt Storage-Battery.

Switch Position 1, valve as cathode (normal position).

Switch Position 2, valve as anode (current reversed).

(4) To dispose of a spent batch of electrolyte, the *cold* pot is put in a sink, and water (preferably warm) is run directly onto the solidified melt by means of a rubber hose connected to the faucet.

(5) If the bath contains an appreciable amount of lead salts, or if the valve to be cleaned had a large deposit of lead compound, a thin gray film of lead may remain adhering to the steel. This can be removed by reversing the current for 10 sec. before removing the valve from the bath. In this case, the metal may take on a golden tinge which is probably due to a very thin coating of iron oxide. The double-throw switch illustrated in Fig. 2 facilitates this operation. When only forgings, scaling specimens, and the like, are to be cleaned, this switch may be omitted.

Discussion

The efficacy of the method is illustrated in Figs. 3 and 4, which show the head and the seat, respectively, of an exhaust valve before and after cleaning. It is clear from these illustrations that the exact condition of the underlying metal could not be forecast by inspection prior to the cleaning operation. Deposits of the type illustrated here could not be cleaned off mechanically without removing some of the metal.

Separate tests made on polished specimens have shown that the loss of metal during the cleaning process is practically nil. Although the method, as illustrated, is particularly adapted to

the cleaning of exhaust valves, it has been found equally satisfactory with scaling specimens, and in removing forging scale.

Precautions

(1) Caustic soda causes very serious burns. The danger of handling it in the present work may come either from exposure to the powdered material when making up melts or, more seriously, from spattering of molten material. The operator should wear a laboratory coat with sleeves (not a sleeveless apron), gloves with gauntlets, and goggles, whenever he is handling the caustic soda or opening the bath, whether to insert or remove valves or whether merely to inspect or stir the melt.

(2) The stirrer or any object which has been in contact with the melt will be covered with caustic soda. This will absorb moisture, and, if the object is put back into the bath without precautions, serious spattering may occur. It is best to insert the stirrer in the bath through the spout, before removing the lid, to confine any spattering which may occur.

(3) When a hollow-stem valve with driven-in plug was heated in the electrolytic bath in this laboratory, the plug was blown out, fortunately without causing any accident. Valves of that type are used only on some aircraft engines. They should be tested prior to cleaning by heating to 400 deg. cent. in a place where failure would cause no damage.

Salt or sodium-cooled hollow-valves, or other valves with welded-in plugs, can be handled safely.

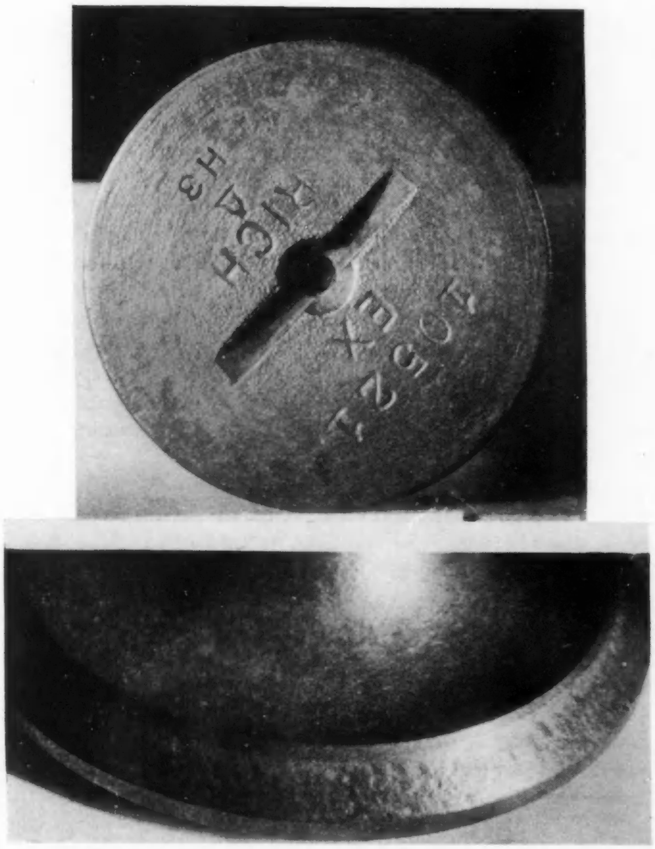


Fig. 4—Exhaust Valve, Enlarged, after Cleaning

Note that the condition of the underlying metal could not be surmised from inspection of the valve before cleaning as shown in Fig. 3.

Newark Transportation Meeting

(Continued from page 18)

fully covered with sheet metal as to interfere with good cooling of brake drums and fuel lines.

Mr. Horine spoke enthusiastically about the Scarab which he said not only has a very clean exterior but is a pioneer in the use of a tubular frame which is a part of the body structure and requires no separate chassis frame. He said that the Scarab rides remarkably well even over very rough ground and can take corners safely at high speed partly because the "oleo" type of suspension has its points of support above the center of gravity. He commented favorably also on the movable seats; on the ventilation system which takes air in at the top and draws it out near the floor; on the use of construction which gives maximum width and greatest wheelbase for a given overall length, affording plenty of space inside the car for both passengers and baggage.

In this regard the chairman said that he felt that Mr. Stout is entitled to great credit for the Scarab design.

In response to a question about any difficulties of steering or "aiming" a car in which the driver sits very close to the front, Mr. Wolf indicated that this had not proved a problem in the metropolitan types of buses with engine in the rear and probably would not be with rear-engine cars. Asked about the possible use of Diesel engines in passenger cars, he indicated that they now appear of doubtful value for reasons which had been brought out in the Diesel session. In respect to door handles that protrude into the air stream on present cars, Mr. Wolf indicated that this fault will probably be overcome by the use of recessed handles in the future. There is now a design for such a handle, he stated. They spring out for grasping when a button is pressed or key turned, but are automatically withdrawn into the recess when the door is closed. As to space available in bodies of cars with rear engines, Mr. Wolf said that the Scarab is excellent in this respect and avoids the need for a tunnel such as is required in cars with front engine and rear drive when the floor is very low.

Safety Rally

One of the two concluding sessions on Friday evening was a safety rally held in the Public Service Terminal Building. Fred C. Rosseland, of the Newark Safety Council, acted as chairman.

The first speaker was Ted B. Rodgers, president of the American Truck Association. He said that he felt that Mr. Winchester would be better qualified than he to speak of safety, as his fleet of Esso trucks has a record of not causing a death or accident during all last year. Recently, said Mr. Rodgers, he had called on President Roosevelt and the first question he asked was, "What are you men doing about this matter of safety?"

Every year, Mr. Rodgers added, insurance rates go higher and higher, even though a particular company may not have any accidents, it still has to pay these high rates.

The second speaker was J. Russell Craig, who for many years has studied motor accidents, and told how to avoid them. He said that truck drivers can often teach the passenger-car driver some things about courtesy and safety. According to the National Safety Council, the number of fatalities caused by passenger-car drivers has increased 60 per cent, whereas those caused by truck drivers have increased about 8 per cent, and those caused by bus drivers have decreased.

"Time Marches On!" at Annual Dinner Featuring Stout and "Senator" Ford

Adolf Gelpke, chairman, Annual Dinner Committee, and Arthur Pryor, Jr., director of the March of Time, talk over the success of the radio feature which was staged as part of the dinner program

MARCH OF TIME, the dramatized news radio program, was a major feature of the Society's Annual Dinner, Nov. 4, at the Hotel Commodore. More than 1000 members and guests witnessed the first presentation of this program outside of the Columbia Broadcasting studio and heard President William B. Stout proclaim that automotive engineers have been busy remaking the economics, the wealth and the social structure of the world.

Acting as toastmaster for the evening, Mr. Stout said, "Engineers may have thought that they were designing and building automobiles, but they were doing more. They were demonstrating economic laws which they have discovered during the past years. They were proving that wealth means not money, but better average living conditions for average men and women.

"Every type of well meaning ignorance and sanctified asininity," he continued, "has done its best to block development in the interest of professional theory. You cannot legislate economic improvement any more than you can legislate the weather. You discover economic principles just as you discover the principles of physics, chemistry, and other sciences.

"Not only are 5,000,000 people employed directly in manufacturing motor-vehicles, but this huge employment has shown that higher wages, shorter hours, a more even distribution of wealth and care for the aged are industrial and economic principles and are not to be confused with legislation."

Mr. Stout went on to say that as long as politics interfere, or as long as the sweat shop, government projects or other hangovers of the old system prevail, we will always have labor troubles. He added that unless the principles of economics win over the wild-eyed theories we will always be ashamed of our civilization.

Pioneering Must Continue

"The automotive industry is by no means perfect," he said. "It must and will continue to pioneer. As it does, and when other industrial groups come along, we will be in a fair way to save civilization's foundation.

"As a matter of proven fact," Mr. Stout added, "the only benefactors of mankind today are the employers. One large automotive employer takes out of every three dollars of his operations one cent. This penny represents plant, equipment and other items of this sort—and his profit. If that's not benefaction I don't know the meaning of the word," he said.

C. D. Jackson, assistant to the president, Time, Inc., introduced the March of Time program by likening the dramatic presentation of new models at the automobile show to dramatic presentation of news by March of Time. The automotive industry furnishes more variegated news, he said, than any other industry—news of science, of steel, of employment, of business, of finance, and of the happiness of the every-day people of this country. The automotive engineers have, through ingenuity and genius, permitted all of us to get great value for our automotive dollar, he said, quoting from a survey made by *Fortune,* "A thousand dollars spent for an automobile will buy two thousand dollars worth of automobile. A thousand dollars spent toward a house will buy about half that amount of house."

Dramatizing News

Mr. Jackson explained that in 1929 *Time* first experimented with radio for dramatizing journalism. At that time stories from the magazine were rewritten, mimeographed and sent by air mail to stations which wanted fifteen minutes of news occasionally. In the following year the news was acted out, recorded and the records sent to the broadcast stations. In 1931 *Time* broadcast a weekly half-hour program over the national network of the Columbia Broadcasting system. This continued through the 1934-1935 season, with Remington-Rand sponsor for the 1933-1934 season as well as for part of the following season. This last fall the program started as a daily event for a fifteen-minute period. This necessitates a permanent staff of a managing editor, six scriptwriters, an 18-piece orchestra, 25 actors, secretaries, technicians and men-at-arms who are kept busy from nine in the morning until 10:45 at night when the broadcast is completed. The sponsorship is shared by *Time* and Remington-Rand.

"Senator" Ford, who had spent the day looking over the new models at the automobile show, maintained his usual high record of laughs per minute, when he talked humorously of what he had seen.

Mr. Stout introduced the following men seated at the speakers' table: Adolf Gelpke, chairman, S.A.E. Annual Dinner Committee; Robert S. Archer, president, American Society for Metals; Arthur S. Tuttle, president, American Society of Civil Engineers; Henry R. Sutphen, president, National Association of Engine and Boat Manufacturers, Inc.; E. T. Satchell, president, Motor and Equipment Wholesalers Association; Mason T. Rogers, president, Motor and Equipment Manufacturers Association; K. D. Smith, presi-

dent, Tire and Rim Association, Inc.; Pyke Johnson, vice-president, Automobile Manufacturers Association; Roy F. Britton, director, National Highway Users Conference; Vern R. Drum, president, Hupp Motor Car Corp.; R. F. Black, president, White Motor Co.; Guy W. Vaughan, president, Curtiss-Wright Corp.; Eugene L. Vidal, director, Bureau of Air Commerce; William A. Irvin, president, U. S. Steel Corp.; Byron C. Foy, vice-president, Chrysler Corp.; Senator Ford; William B. Stout, president, S.A.E.; C. D. Jackson, assistant to the president, Time, Inc.; R. R. Teetor, presidential nominee, S.A.E.; E. L. Cord, president, Cord Corp.; Thomas H. MacDonald, chief, Bureau of Public Roads; I. B. Babcock, president, Yellow Truck and Coach Mfg. Co.; Dr. L. J. Briggs, director, National Bureau of Standards; Roy Faulkner, president, Auburn Automobile Co.; Robert C. Graham, vice-president, Graham-Paige Motors Corp.; A. J. Chanter, president, Pierce-Arrow Motor Car Co.; Alfred Reeves, vice-president and general manager, Automobile Manufacturers Association; A. L. Viles, president, Rubber Manufacturers Association, Inc.; F. W. A. Vesper, president, National Automobile Dealers Association; T. D. Pratt, president, New York State Motor Truck Association, Inc.; F. H. Russell, president, Manufacturers Aircraft Association, Inc.; H. S. Vassar, president, American Society for Testing Materials; E. B. Meyer, president, American Institute of Electrical Engineers; J. F. Winchester, chairman, Metropolitan Section, S.A.E.

Seated at the Past-President's table were: Howard E. Coffin, H. W. Alden, G. W. Dunham, J. G. Vincent, David Beecroft, B. B. Bachman, T. J. Litle, Jr., J. H. Hunt, W. G. Wall, Vincent Bendix, H. C. Dickinson and D. G. Roos.

B. B. Bachman, chairman of the nominating committee, read the names of officers nominated for 1936. Ralph R. Teetor, nominee for president, was introduced by Mr. Stout. In a short talk Mr. Teetor expressed his appreciation and said that he anticipates generous cooperation from the members in making 1936 a successful year for the Society.

The outstanding success of the dinner was the result of the efforts of the Dinner Committee: Adolf Gelpke, chairman, H. F. Huf, Austin Wolf, Leslie Peat and A. L. Beall.

"Judy" McCormick Completes 25 Years of S.A.E. Service

The S.A.E., represented by 1000 members and guests at the Annual Dinner, rose to its feet in a spontaneous ovation to "Judy" McCormick when she was escorted to the speakers' table by three Past Presidents to receive from President Stout the official appreciation for her completion of 25 years of service to the Society.

Formalized in a resolution adopted unanimously by the Council at its meeting on Nov. 2, the appreciation read by President Stout was as follows:

> WHEREAS Julia A. McCormick has completed twenty-five years of effective and proficient service to the Society of Automotive Engineers and has borne with notable success responsibility for a variety of complex functions bearing vitally on the stability and welfare of the Society, and
>
> WHEREAS the graciousness as well as the efficiency with which she has performed these functions has earned the unstinted praise of twenty-four presidents and two general managers of the Society under whose supervision her work has been done, and
>
> WHEREAS she has brought to the Society as a whole and to thousands of its individual members a glowing personalization of that spirit of goodwill which is the essence of cooperative professional effort, therefore,
>
> BE IT RESOLVED that the Council of the Society shall and hereby does express to Julia A. McCormick in behalf of the members of the Society of Automotive Engineers sincere and profound appreciation for her warm loyalty and continuous devotion to their interests and for her conspicuous service in furtherance of the Society's ideals and objectives.

For the Council

JOHN A. C. WARNER, *Secretary* — W. B. STOUT, *President*

Julia Anna McCormick

" . . . . a glowing personalization of that spirit of goodwill which is the essence of cooperative professional effort . . . . "

New Members Qualified

These applicants who have qualified for admission to the Society have been welcomed into membership between Oct. 10, 1935, and Nov. 10, 1935.

The various grades of membership are indicated by: (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate Member; (SM) Service Member; (FM) Foreign Member.

BEALE, STANLEY T. (J) engineering instructor, Aeronautical University, Inc., 1338 South Michigan, Chicago.

BLAIR, GEORGE W. (M) vice-president, Mishawaka Rubber & Woolen Mfg. Co., Mishawaka, Ind.; (mail) 345 Edgewater Drive.

CARPER, WILLIAM F. (A) division lubrication engineer, General Petroleum Co., Woodlark Building, Portland, Ore.

FARMER, HAROLD OATRIDGE (FM) chief engineer, Petters, Ltd., Yeovil, England.

FARNUM, SAMUEL BARNARD, JR. (J) junior engineer, Standard Oil Co. of New Jersey, 26 Broadway, New York City; (mail) 444 East 39th Street, Paterson, N. J.

GRANT, ROBERT (A) superintendent, final assembly department, Nash Motors Co., Racine, Wis.; (mail) 1225 South Main Street.

HAWXWELL, FREDERICK WILLIAM (FM) director, Hawxwell & Jones, Ltd., Campbell & Commonwealth Street, Sydney, New South Wales, Australia.

HESS, ROBERT A. (M) engineer, Standard Oil Co. of New Jersey, 26 Broadway, New York City; (mail) 255 Avenue A, Bayonne, N. J.

KELLY, H. H. (M) senior administration officer, U. S. Bureau of Public Roads, City of Washington; (mail) 3715 35th Street, N. W.

McDONALD, NEIL J. (J) research engineer, Minneapolis-Moline Power Implement Co., Minneapolis; (mail) 3932 Pleasant Avenue.

NEELY, GEORGE LEONARD (M) research engineer, lubricating research, Standard Oil Co. of California, Library, Richmond, Calif.

NOLAN, JOSEPH L. (A) assistant manager, oil department, Farmers Union Central Exchange, Inc., Box G, St. Paul, Minn.

POINTER, ROBERT WILLIAM (A) manager, truck equipment department, Beall Pipe & Tank Corp., Kenton Station, Portland, Ore.

SHEPARD, DAVID A. (FM) European representative, Standard Oil Development Co., 26 Broadway, New York City; (mail) 82 Avenue des Champs Elysees, Paris 8, France.

SHOCKEY, ELI G. (A) 200 Westinghouse Avenue, Wilmerding, Pa.

SMITH, FRANK M., LIEUT. (M) general manager, Stout Engineering Laboratories, 2124 Telegraph Road, Dearborn, Mich.

TERRILL, F. O. (M) charge of transport and warehousing department, Kroger Grocery & Baking Co., 35 East Seventh Street, Cincinnati.

TROWNSELL, HAROLD C. (A) truck manager, Chevrolet Motor Co., Chicago; (mail) 410 North Michigan Avenue, Room 482.

WELLS, JUSTIN HENRY (FM) director, Germ Lubricants, Ltd., 735-41 Salisbury House, Finsbury Circus, London E.C. 2, England.

WILSON, ARTHUR H. (A) sales engineer, Peter Pirsch & Sons Co., Post Office Box 727, Atlanta, Ga.

Applications Received

The applications for membership received between Oct. 15, 1935, and Nov. 15, 1935, are listed herewith. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

BASSETT, GEORGE BRINKERHOFF, West Coast manager, Weaver Manufacturing Co., Springfield, Ill.

BETTS, FREDERICK HILL, commercial fleet sales, Colonial Beacon Oil Co., Inc., New York City.

BEVERLY, BELMONT FREEBORN, engineer, Socony-Vacuum Oil Co., Inc., Albany, N. Y.

BLACK, EDWARD MARTIN, technical representative, General Motors Near East S/A, Alexandria, Egypt.

BRAND, CHARLES J., field engineer, Firestone Tire & Rubber Co., Akron, Ohio.

BRODERS, C. E., general superintendent, The Govro-Nelson Co., Detroit.

BROWN, MORRIS C., engineer, Carter Carburetor Corp., St. Louis, Mo.

BUNCE, HAROLD, superintendent of transportation, The California Oregon Power Co., Medford, Oregon.

BURKE, JOHN J., general manager, General Tire Co. of New York, New York City.

BURT, GORDON, lubrication engineer, Asiatic Petroleum Co., Ltd., Singapore.

CARPENTER F, IVAN, Parque Central de Aviacao, Campo dos Affonsos, Rio de Janeiro, Brazil.

CASE, LELAND R., shipping clerk, California Packing Corp., Terminal Island, Cal.

CHAMBERLAIN, ALAN HAWKER, manager, engineering department, Australian Ball Bearing Co., W. Melbourne, Australia.

CHAMBERS, HARRY B., technical director, Jaray Streamline Corp., New York City.

COLVIN, R. H., chief engineer, Burd Piston Ring Co., Rockford, Ill.

COWELL, WILLIAM SIDNEY, service engineer, Canadian Raybestos Co., Ltd., Peterborough, Ont., Canada.

DOLINKA, JACK LOUIS, 150 Ross Street, New York City.

EDWARDS, BRINT, engineer, United Engine and Machine Co., San Leandro, Cal.

ENSIGN, PAUL W., president, Ensign Carburetor Co., Ltd., Huntington Park, Cal.

ERSKINE, HAROLD E., president, Wheel & Rim of Canada, Ltd., Toronto, Ont., Canada.

FORSTER, HENRY PETER, engineer, Roger-Smith Hotel Corp., New York City.

FRAZIER, GEORGE FLETCHER, student, Mass. Inst. of Technology, Lowell School, Cambridge, Mass.

GARRITY, DONALD, instructor, Board of Education, City of New York, Brooklyn, N. Y.

GIESLER, ARTHUR E., Letz Manufacturing Co., Crown Point, Ind.

GRAINGER, ALBERT EDWARD, manager manufacturers sales department, Goodyear Tire & Rubber Co. of Canada, Ltd., New Toronto, Ont., Canada.

GRENFELL, JOHN GRANVILLE, Brooklands Aerodrome, Byfleet, Surrey, England.

GUPTA, ARABINDA, works foreman, Motor Vehicle Department, Corporation of Calcutta, Calcutta, India.

HAMILTON, WILLIAM H., division garage superintendent, Shell Eastern Petroleum Products, Inc., Brooklyn, N. Y.

HART, HARRISON L., Mid-west district manager, Wico Electric Co., E. Springfield, Mass.

HERDT, WILLIAM, chief engineer, Roger Smith Hotels Corp., New York City.

HIXON, THOMAS E., service manager, General Motors Truck Co., Memphis, Tenn.

HUGHES, ROBERT E., fleet manager, Caswell Motor Co., New York City.

KAPLAN, PHILIP, salesman, Champion Spark Plug Co., Toledo, Ohio.

KEERINS, GRATTAN D., engineer, Trombly Truck Equipment Co., Portland, Oregon.

KIMBALL, SAMUEL M., superintendent of garages, Shell Eastern Petroleum Products, Inc., New York City.

JOHNSON, HAROLD O., vice-president and sales manager, Bound Brook Oil-less Bearing Co., Bound Brook, N. J.

JOHNSTON, WILLIS A., chief chemist, Bradford Penn Refining Corp., Clarendon, Pa.

LEWIS, GEORGE WILLIAM, draftsman, Caterpillar Tractor Co., San Leandro, Cal.

LOVELL, RICHARD R., service man, Illinois Bell Telephone Co., Chicago.

LYMAN, H. G., manager, industrial sales department, Pennzoil Co., Los Angeles, Cal.

McGILLIVRAY, JOHN R., assistant general manager, The Perfect Circle Co., Ltd., Toronto, Ont., Canada.

McLAREN, STEWART C., commercial salesman, Maclin Motors, Ltd., Calgary, Alta., Canada.

MERRITT, THEODORE R., assistant engineer, Ozalid Corp., New York City.

MEYER, O. B., garage superintendent, J. P. Finlay & Son, Portland, Ore.

MOORE, HICKMAN WALKER, assistant professor, University of Alabama, University, Alabama.

MORRISON, LACEY H., editor, "Diesel Power," Diesel Publications, Inc., New York City.

NASON, F. ALEX, vice-president, The Lubri Zol Corp., Cleveland, Ohio.

NOHAVEC, FRED R., engineer, Donaldson Co., Inc., St. Paul, Minn.

PARKINSON, LESLIE RENDALL, research engineer, Anglada Motor Corp., New York City.

PATTERSON, ALBERT M., 160 E. 72nd St., New York City.

PIPER, CHARLES M., general manager, automotive department, Johns Manville Sales Corp., New York City.

RAY, WALLY, salesman, The Texas Co., New York City.

ROSE, CECIL, field engineer, Perfect Circle Co., Ltd., Toronto, Ont., Canada.

ROURKE, J. B., sales manager, General Tire Co. of New York, New York City.

(Continued on page 30)

The Holabird Quartermaster Depot of which Colonel Taylor is a ranking officer has become celebrated wherever motor-vehicles are operated and maintained in the United States. Colonel Taylor's view of the S.A.E. is particularly interesting because he is representative of scores of responsible officers in the United States services who are members of the Society, and with whom the Society has cooperated through such institutions as its Ordnance Advisory Committee.

"I look forward to its leadership – –"

Col. Brainerd Taylor says of the S. A. E.

"IN my work of the past sixteen years, connected with the development of military motor transport required in our national defense, the S.A.E. has assisted, encouraged and inspired me through the JOURNAL, its meetings and individual members. I look forward to its leadership in developing both commercial and military motor transport as coordinating factors in our now entirely mechanized systems of air, water, rail and highway transportation."

THIS PAGE IS PRINTED FOR THE INSPIRATION OF OUR PRESENT MEMBERS—FOR PRESENTATION TO PROSPECTIVE MEMBERS

What Members Are Doing

K. T. Keller, president of Chrysler Corp., has recently been reelected president of the board of trustees of the Detroit Safety Council.

H. M. Northrup recently has been appointed chief engineer by the Hudson Motor Car Co. Mr. Northrup affiliated with Hudson as assistant metallurgist in 1920 and was made metallurgist in 1922. In 1930 he became assistant chief engineer. Active in S.A.E. work Mr. Northrup has been a member of the Lubricants Division of the Standards Committee and of the Automobile Group of the Extreme-Pressure Lubricants Subcommittee of the Research Committee since 1931.

H. M. Northrup

Ethelbert Favary, consulting engineer, is conducting a course in Automotive Engineering and High Speed Diesel Engines at the Frank Wiggins Trade Evening School in Los Angeles, Calif.

C. H. L. Wynne, formerly engineer in charge of carburetor and clutch control division of Bendix, Ltd., is affiliated with D. Napier & Sons, London, as carburetor engineer in the research department.

A. E. Ulmann recently has joined Aviation Equipment and Export, Inc., as export sales manager.

Arthur L. Wight is proprietor of Wight Engineering & Sales Co., electrical contractors and radio and refrigerator distributors, Fredericksburg, Va. Mr. Wight previously was on the sales staff of Electrolux, Inc.

Harley W. Drake, until recently superintendent of automotive equipment, Portland Gas & Coke Co., has joined the A. F. Blangy Motor Co. as service engineer. Mr. Drake is nominee for vice-president of the Society representing Transportation and Maintenance Engineering Activity for 1936 and for many years has been a vital force in the Oregon Section, of which he was chairman three times.

Harley Drake

Foreign Member Contributes

Maurice Platt, author of the paper on British and Continental car design trends which appears in this issue, beginning on page 425 in the Transactions Section, is a prominent foreign member of the S.A.E. A member also of the British Institute of Automobile Engineers, he was awarded the Crompton medal for a paper on brakes in 1931.

He has been on the staff of *The Motor* since 1923, having been technical editor since 1930. Prior to that time, he was a lecturer in engineering in a London College and from 1919 to 1921 was on the technical staff of Albion Motors, Ltd., in Glasgow. During the World War, Mr. Platt was an airplane pilot and later a technical officer in the Royal Flying Corps and the Royal Air Force. He was graduated from Sheffield University in 1916 with a degree of Master of Engineering.

Stanley R. Thomas, has recently been appointed chief engineer of the Auburn Automobile Co. He was formerly experimental engineer with the Auburn company.

Stanley Thomas

Temple N. Joyce has resigned from the presidency of the Bellanca Aircraft Corp., Newcastle, Del., and has become an executive of the Great Lakes Aircraft Corp. at Cleveland.

H. H. Kelly has been made chief of the Safety Section of the new Motor Carrier Bureau of the Interstate Commerce Commission. He was previously connected with the Division of Highway Transport, Bureau of Public Roads, United States Department of Agriculture.

Eugene A. Cousins has joined Chrysler Corp., export division, as boxing engineer.

Louis Paul Croset is designing engineer with the National Gas & Oil Engine Co., Ltd., Ashton-Under-Lyne, England. He was formerly engineer-designer with Blackstone & Co., Ltd., Stamford, England.

William A. Catalano is in the experimental department of Thompson Products, Inc. He formerly was with the Standard Oil Co. of Ohio as sales engineer.

Thomas Douglas MacGregor, who has been attending New York University as a graduate student, recently has joined the Douglas Aircraft Co. in the capacity of apprentice engineer.

Paul C. Spiess has affiliated with Gyro Airlines, Inc., located at the Municipal Airport, Denver, as engineer. He was formerly with the American Gyro Co. as engineer.

J. E. Padgett recently was appointed vice-president of engineering by the Spicer Manufacturing Corp. Mr. Padgett has been affiliated with Spicer since 1924. Active in S.A.E., he was vice-president representing Production Engineering in 1932. He has been a member of the Production Activity Committee since 1931 and has served on the Production Division of the Standards Committee and as a member of the Military Motor Transport Advisory Committee.

J. E. Padgett

Harry G. Stoddard, president of the Wyman-Gordon Co., has recently been elected to the board of directors of the United Aircraft Corp.

W. G. Retzlaff has joined the Fruehauf Trailer Co. in charge of sales engineering. He was previously sales engineer with the General Motors Truck Co. Mr. Retzlaff was formerly with the Fruehauf company during the years 1922 to 1930.

J. Harold Hunt, formerly chief engineer of the Motor Wheel Corp., has been named vice-president of engineering.

George H. Kublin has joined General Motors Export Division as assistant chief engineer. He will be located at the Cadillac Plant in Detroit. Mr. Kublin was previously chief engineer of the Auburn Automobile Co.

George H. Kublin

H. N. Charles, formerly chief draftsman of the M. G. Car Co., Ltd., Berks, England, has recently joined Morris Motors, Ltd., Cowley, Oxford, England, as assistant to chief designer.

Carroll M. Aument is now with the Sikorsky Aircraft Corp. as engineer. He was previously engineer with the Glenn L. Martin Aircraft Co.

S. P. Thacher, U. S. Rubber Products, Inc. of Detroit, has been made manager of the tire engineering and service division. His former position was manager of the technical division.

Per K. Frolich, who has been director of research of the Standard Oil Development Co., has recently been made chief chemist.

William Everett Miller has been appointed sales engineer for Canada by the Wilkening Manufacturing Co., Canada, Ltd. Prior to this he was sales and service representative.

A. F. Bocksruker is now draftsman in the Tractor Works of the International Harvester Co., Chicago. Before this change he was with the Allis-Chalmers Manufacturing Co.

Alfred P. Sloan, Jr., president, General Motors Corp., will be the principal speaker at the dinner opening the annual Congress of American Industry held, Dec. 4, in conjunction with the annual convention of the National Association of Manufacturers.

H. M. Daniels has been named supervisor of the new consolidated Eastern sales division of the Four Wheel Drive Auto Co. Mr. Daniels was previously vice-president and New York branch manager of the Four Wheel Drive Sales Co.

Herbert Clark has recently been appointed managing director of Messrs. Tangyes Ltd., England. Mr. Clark was affiliated with Rolls-

Herbert Clark

Royce in this country for ten years. After his return to England he was managing director of Bendix, Ltd. in Birmingham.

Miles G. Hanson has joined the Norwood Electric Foundry Co. as general manager. He was formerly connected with the AC Spark Plug Co.

Nils G. Bjorck, formerly commercial car designer, Continental-Divco Co., recently affiliated with Ward LaFrance Truck Corp. as special designer of motor trucks.

Claude Fulton Quackenbush, who has been head, mechanical engineering and airplane departments, Polytechnic College of Engineering, Oakland, Calif., recently joined the Bellingham Diesel Works, Bellingham, Wash., as chief engineer.

Edgard C. De Smet is research body engineer with the engineering staff of the Chrysler Corp., Research Division. He formerly was affiliated with the Hudson Motor Car Co. as body designer. Mr. De Smet who originated

E. C. De Smet

Planography, a scientific method of surface design, presented papers on the subject at the Annual Meetings of the Society in January 1934 and 1935.

Frank M. Bender

Frank M. Bender has been elected vice-president in charge of operations of the White Motor Co. He was, until recently vice-president and general manager of the Lycoming Mfg. Co. He had been affiliated with the Lycoming company since 1911 when he entered its employ as draftsman and tool designer.

Hugo K. Moren has recently affiliated with Bolinder-Munktell, Eskilstuna, Sweden, as Diesel engine designer.

Walter O. Rogers is now with the MacDonald Truck and Manufacturing Co., San Francisco, Calif., as draftsman.

H. Horton Turner is now development engineer of Fairbanks Morse & Co., Beloit, Wis. His prior connection was with the International Harvester Co., as heavy fuel, vaporizer and development engineer.

Charles H. Chatfield has changed his position with United Aircraft Manufacturing Corp. from that of chairman of the Technical

C. H. Chatfield

Advisory Committee to director of research. Mr. Chatfield is vice-president of the Society representing the Aircraft-Engineering Activity.

Garland Powell Peed, Jr., who was formerly scientific aide, National Advisory Committee for Aeronautics, is now affiliated with the Kinner Airplane and Motor Co. at Glendale, Calif.

A. J. Boardman, vice-president and general manager, Eastern Massachusetts Street Railway Co., Boston, recently has been appointed vice-chairman of the Bus Division of the American Transit Association.

H. I. Sullivan, with the same company as superintendent of Rolling Stock and Shops is serving as chairman of the Bus Division Committee on garage construction and layout.

Martin Schreiber, general manager in charge of plant, Public Service Coordinated Transport, Newark, N. J., is chairman of the committee on equipment development.

Benjamin F. Heald is now affiliated with the Autocar Co. as draftsman-designer. Before joining Autocar he was with the J. G. Brill Co.

Dhiren N. Ray, in charge of the service department, Leyland Motors, Ltd., Calcutta, India, visited S.A.E. headquarters while in New York to attend the automobile show. He also attended the Annual Dinner of the Society.

E. D. Herrick has been appointed assistant general manager of the automotive division of the Lycoming Manufacturing Co.

Martin S. Mansson has joined Air Associates, Inc., as designer. He was previously designer with Eclipse Aviation Corp.

Oscar A. Eskuche is practising as consulting engineer, specializing in automotive and industrial surveys, located in Warwick, N. Y. Mr. Eskuche was last affiliated with Chas. F. Kellom & Co. as New York district manager.

G. A. Foisy is affiliated with the Waterbury Tool Co. as an engineer.

Joseph Geschelin, Detroit Technical Editor, Chilton Publications, will address the International Business Machines Club at Endicott, N. Y., Dec. 10. The topic of his talk is "Behind the Scenes with the New Models in the Automotive Industry."

William O. Charles is president of Charles Brothers, Inc., automobile dealers, Pueblo, Colo. He was with Community Motors, Inc., New Orleans, as Pontiac sales manager.

John Hanson has joined the Fairchild Aircraft Company recently as layout draftsman.

Emery H. Fahrney

Emery H. Fahrney, president of the Universal Motor Co., and a member of the Society since 1927, died on Oct. 7, at the age of 59. He was buried at the Graceland Cemetery, Chicago, on Oct. 10.

Mr. Fahrney was for many years interested in automotive engineering. In 1898 he designed a two-cylinder marine engine and a single-cylinder automobile engine. These engines had some features that were new at the time and not used in general practice until some years later. The lubricating system was sight feed (virgin oil) to all bearings, the crank pins lubricated through a drilled crankshaft and the cylinders from the oil thrown off by the connecting rods. He constructed a spark-plug built of a number of mica washers and successfully ran the engine by use of a jump spark. This was discontinued later in favor of the make and break spark for which Mr. Fahrney obtained a patent in 1902. In 1908, with Louis J. Monahan, he designed and manufactured a four-cylinder valve-in-head engine.

D. Roberts Harper

D. Roberts Harper, 3rd, a member of the Society since 1922 and a physicist of the Carnegie Institute of Technology, Pittsburgh, Pa., died on Oct. 19, 1935. He was 50 years old.

Graduated from the University of Pennsylvania in 1905, Mr. Harper received a degree of Doctor of Philosophy from that institution in 1910 and for many years was a member of the staff of the National Bureau of Standards. In 1927 he joined the General Electric Company as consulting engineer and physicist and remained there until 1931, when he went to Carnegie Institute of Technology, where he specialized in coal research.

News of the Society

Rear End Slighted in Present Streamlining

● Northwest

Discussing streamlining before the Oct. 25 meeting of the Northwest Section, F. K. Kirsten, professor of aeronautics, University of Washington, stated that the shape of the nose of a vehicle does not affect the magnitudes or directions of forces acting on that section because the entry-wedge of air is always pushed up by the entrance of the body into the air; however, the contour of the tail is very important to obtain the least resistance. On this basis the speaker criticized the modern so-called streamlined automobiles which are well streamlined in front, where it is unnecessary, and have short blunt rear ends without the essential double-curvature extremely slim shape.

Armed with colored chalks, Professor Kirsten sketched the action of air flowing over a streamlined body. By tracing the path of a particle of air he diagrammed the forces produced by centrifugal accelerations of the particle as it climbed over the entry-wedge, slid over the maximum point and then closed in over the double-inflected tail of the body. He explained that this established three zones of forces: compression on the nose and tail and tension in the middle section. Resolving these forces into components parallel to the axis gave four zones; retarding forces on the nose and just back of the widest section and helping forces just ahead of the widest section and on the tail. In frictionless fluid these components would completely balance out, but in real fluids, like air, an unbalance remains which is the resulting air resistance.

The speaker further explained that a cylinder in an air stream will have a wake of vortices alternating from side to side, but that a rotating cylinder will produce but one vortex and have a resulting force acting normal to the line of flow. This, he said, is the so-called Magnus effect and is the basis of the well-known Flettner rotor. Another development of this principle is the airfoil.

In applying streamlining to moving vehicles, the incentive is amplified by the fact that the power required to overcome air resistance increases as the cube of the speed, while it is merely directly proportional in the case of bearing friction and rolling resistance. In addition to this basic air resistance, skin friction becomes important on long objects where a dragging boundary air layer piles up depending on the length of the surface.

Professor Kirsten elaborated these basic principles and applied them to such problems as ship hull design, high-speed trains, car ventilation, biplane versus monoplane, heat transfer, oil versus pulverized coal burners and steam turbines. He stated that these theories are new and still in the development stage and that much experimental work is yet to be done. He then described a wind tunnel under construction at the University of Washington with a test chamber 8 by 12 ft. in section, powered with 1500 horsepower to produce a wind velocity of 250 m.p.h. Most of the instruments were designed and are to be constructed in the University shops. It will be possible to complete a test on a model in 15 minutes automatically.

G. E. Bock and Sherman W. Bushnell participated in an interesting discussion of Professor Kirsten's paper.

More than forty members and guests were present at the meeting following a dinner attended by 19 members at the Mayflower Hotel in Seattle. George E. Bock, vice-chairman of the Section, presided in the absence of Chairman James H. Frink.

N.Y.U. Student Branch Starts New Season

● New York

The Student Branch of the Society at New York University held its organization meeting on Oct. 14 at Guggenheim Hall. Thomas Bergmann, chairman, spoke on the functions of the S.A.E. A general business meeting concluded the program.

On Oct. 23 twenty members of the Branch gathered at Lawrence House for a program of moving pictures showing different phases in the production of automobiles. Refreshments were served at the conclusion of the program.

Engineering Contrasted To Boondoggling

● Detroit

A talk by Charles E. Wilson, vice-president, General Motors Corp., climaxed the afternoon and evening sessions of the Detroit Section, on Nov. 11. Speaking before an audience that packed the Grand Ballroom of the Book-Cadillac Hotel, Mr. Wilson differentiated "boondoggling" from engineering, defining boondoggling as any useless, ineffective activity, such as making useless articles out of discarded junk, or where the social value of the result is out of all proportion to the money and effort expended. During the depression years, the automotive industry has been particularly free from boondoggling activities, he said. As a result, we have better design and better performance of cars made on better equipment. The men who have been put to work by the automotive industry, both in the industry itself and in allied industries, Mr. Wilson continued, have produced something useful and of great social value. They have made it possible for hundreds of thousands of people to enjoy motor cars, and have themselves made a good living in so doing.

E. V. Rippingille, business director, General Motors Research Division, who introduced Mr. Wilson, said it was sometimes hard to distinguish pure research from boondoggling. A research executive cannot set a date nor name a definite result for the money expended. It takes a pretty generous attitude on the part of management to make a research division ultimately successful. In his remarks, he also proposed that Detroit activities be expanded to embrace in its membership the higher type of craftsmen and technicians who interpret engineers' ideas and desires in working models.

Besides excellent musical entertainment, a highlight of the evening was a 10-reel Pan American Airways travel film, depicting the "Clipper Ship" route of the entire South and Central American System. The members stayed on far into the night to view it in its entirety.

At the afternoon session, Walter T. Fishleigh, patent expert, spoke on "What Price Progress?" Among the prices we must pay for progress, he named, first, the ability to go ahead, since to stand still is to go back, as the main field passes on; second, hard work and long hours; third, original, independent thinking; and fourth, a liberal amount of fearlessness and risk. A good part of his talk was made up of other sound advice to the young man, since this particular session was under the auspices of the Junior-Student Activities of the Detroit Section. He predicted that we would see four times as much technical progress in the next generation than we had in the last.

N. E. Hendrickson, vice-president and chief engineer of the Mather Spring Co., spoke on spring suspension developments. He began by comparing ancient and modern methods of heat-treating steel and saluted the great strides made in metallurgy in recent years. He then demonstrated with a scale model the factors affecting spring frequency, as well as the phenomena of interference and resonance occurring when springs of different frequencies operate together. Quickly sketching the development of independent springing, he showed how the net result had been to lead back to leaf springs, but with a much softer action than had heretofore been considered possible with the old type of steering gear geometry. Whereas front springs used to have a deflection of 1¾ in. under static load, it is not uncommon to find deflections of 7 in. in present models. Spring frequencies are now within the range of 70-80 cycles per minute as against the uncomfortable 130, although it was back in 1912 when F. W. Lancaster first proposed springs of a frequency to correspond with a walking gait.

Robert N. Janeway, research engineer, Chrysler Corp., presided at the afternoon session.

Barish Discusses Close Tolerances

● Buffalo

The Buffalo section, meeting at the Hotel Statler on Nov. 12, heard Thomas Barish, assistant chief engineer, Marlin-Rockwell Corp., discuss "Precision Manufacture in Quantity Production." He illustrated his talk with slides showing methods used to obtain close tolerances in the production of ball bearings and reasons why close tolerances are necessary.

More than 80 members and guests heard Mr. Barish. There were 22 present at a dinner preceding the meeting.

Diesel Plant Meeting Draws Record Crowd

• Milwaukee

More than 525 members and guests of the Milwaukee Section crowded into an improvised auditorium at the Wisconsin Motors Corp. plant Nov. 4 to hear Moyes J. Murphy, vice-president and general manager of the Murphy Diesel Co., Ltd., talk on "Diesel Engines of High Output." Mr. Murphy, a former chief engineer of the Caterpillar Tractor Co., is the designer of the Murphy Diesel Engine. He used slides to aid him in giving a description of this engine in which many new and unusual features are incorporated. More than an hour of discussion followed the talk.

Earlier in the evening those attending the meeting had been escorted through the plant and were given an opportunity to see the engine in actual operation. Wisconsin Motors Corp. air-cooled engines were also on display. The Murphy Diesel is manufactured in this plant.

Proper Maintenance Lowers Repair Costs

• Baltimore

Fleet operators are growing to realize that preventive maintenance is an important factor in keeping trucks on the road, according to O. M. Brede, director of service, General Motors Truck Co., in his talk before 75 members and guests of the Baltimore Section at the Engineers Club, on Nov. 7. The primary purpose of preventive maintenance is to prevent repairs, but it goes further, he said, in leading to lower maintenance costs, fewer road failures and lower accident rates. To illustrate these points Mr. Brede quoted actual cases where figures had been compiled by fleets before and after the installation of a preventive maintenance system. Then he outlined a system of preventive maintenance that has been tried and found to be simple, easy to operate and effective.

Following Mr. Brede, Espy W. H. Williams, technical editor, Automotive Service Bureau, gave his paper, "Automatic Control of Road Speed to Curb the Mounting Death Toll". In it he maintained that since government of vehicle speed by law is an impossible task, automatic or mechanical control of speed seems the only solution. The speaker advocated that a person violating speed laws should have his operating license revoked until the vehicle he operates is equipped with an approved speed-control governor. Mr. Williams continued by reporting the views of different fleet operators who have had experience with governor-controlled vehicles.

Adrian Hughes conducted a discussion of Mr. Brede's paper which was participated in by superintendents of the larger Baltimore fleets.

Students Hear Drake Analyze New Models

• Oregon

Harley W. Drake, secretary and student branch advisor of the Oregon Section, addressed the second meeting of the Oregon State College Student Branch Nov. 7, discussing "New Features of the 1936 Automobiles." Mr. Drake pointed out that the most important changes in the new cars include: full length water jackets, new balance features, wide adoption of hydraulic brakes and a trend away from the conventional frame resulting in a lower center of gravity.

After his talk Mr. Drake presented gifts from Portland concerns to the automotive department of the college. A water pump and a single-cylinder engine, similar to those used by the U. S. Forest Service, were donated by the Bingham Pump Co. The Weaver Manufacturing Co. presented a one-tenth size automobile chassis built to scale, with front-wheel assembly constructed to allow for adjusting the camber, caster and toe-in. It is designed to run on a belt treadmill to permit studying different wheel angles and their effects.

A feature of the opening meeting of the Oregon State College Student Branch on Oct. 24 was the announcement of the Student Paper Prize Contest sponsored by the Oregon Section. The prizes which will be awarded to the Student Members whose papers on automotive or related subjects are judged the best by the Committee on Student Prizes of the Oregon Section will be: first prize—S.A.E. bronze desk emblem, properly engraved, plus $50 in cash; second prize—S.A.E. bronze desk emblem, properly engraved, plus $25 in cash; third prize—Richfield aviation clock desk set, properly engraved, plus $15 in cash. Besides these awards a cup will be presented to the school department of the winner to hold for the ensuing year. Any department winning it for three years may keep it permanently.

Officers of the Oregon State Student Branch are Robert W. Beal, chairman; Arthur C. Durland, vice-chairman; and Richard Allen, secretary-treasurer. W. H. Paul, assistant professor, mechanical engineering department, was elected faculty advisor.

The 35 members of the Student Branch are backing the current safety program and are taking charge of distributing a series of safety bulletins at the college.

Auto Show Scene Of Section Meeting

• Philadelphia

Keeping close to its subject the Philadelphia Section met Nov. 13 on the floor of the Philadelphia Auto Show at Convention Hall. Dinner was served to 60 members and guests in the Convention Hall dining room. Austin M. Wolf gave his paper, "Automotive Engineering Developments for 1936," which was printed in full in the November issue of the S.A.E. JOURNAL.

At the business meeting preceding Mr. Wolf's talk, Delmar D. Robertson, chief engineer, Wilkening Manufacturing Co., was nominated for section representative on the National Sections Committee.

Body Roominess Makes Better Seats Possible

• New England

In his annual talk before the New England Section on "What's New in the New Models", Dean A. Fales, associate professor, automotive engineering, Massachusetts Institute of Technology, commented on the cars at the National Automobile Show in New York and new developments in design here and abroad. This year, he said, car builders have brought the balance

Candid Camera Snaps Canadian Section in Action

L. P. Saunders made these shots at the Canadian Section dinner meeting in Toronto, Oct. 16. On the right Neil Petersen, Section Chairman, addresses the "mike." Others that we recognize are George Garner, past-chairman; James C. Armer, last year's chairman; and Warren B. Hastings, secretary. In the picture on the left R. M. Thomas is standing facing the camera. ***(The Journal invites other S.A.E. candid cameramen to send shots of S.A.E. subjects).***

of chassis to meet the engine development. Dean Fales remarked that while increased roominess of bodies is an improvement, better seats are possible and the position of the driver's seat can be altered advantageously to permit him better vision. Advancements in riding quality and stability of the new models, he stated, will tend toward better control and increased safety in operation.

Francis I. Hardy, industrial engineer, spoke on efficient operation of motor trucks as a field for operating profits. He gave figures on operating costs of various components of vehicles at increasing mileages showing that some parts, such as electrical systems, while among the low-cost units, cause the greatest number of delays and road failures.

E. F. Lowe, assistant general manager of the Society, attended the meeting and spoke on the progress of the Society and the benefits of membership.

The meeting was held Nov. 4 at the Walker Memorial, Massachusetts Institute of Technology. The dinner preceding it was attended by 36 members and guests. Later arrivals brought the total attendance to 150.

Students View Safety Pictures

• M. I. T.

The Massachusetts Institute of Technology Student Branch held its first open meeting of the year on Nov. 5. Safety was the keynote of the program. G. Ray Smith, New England sales promotion manager for Chrysler, De Soto and Plymouth, showed several sound pictures, including "Everybody's Business," released by the Plymouth Motor Corp.; "Safety With a Thrill," showing spectacular methods of testing Chrysler Airflow cars; and another film which graphically demonstrated the advantages of acquiring safe driving habits.

Speed Saves Time And Time Is Life

• Washington

Justifying speed on the basis that it saves time and consequently saves life, because time is life, Dr. H. C. Dickinson, chief of the Heat and Power Division, National Bureau of Standards, and past-president of the Society, spoke on safety engineering before 50 members and guests of the Washington Section at the University Club on Nov. 11. He pointed out that fatalities due to travel by rail, air and automobile are approximately one per ten million passenger miles and that recent efforts to reduce traffic accidents are not producing satisfactory results. Conditions would improve, he said, if each driver would assume his share of the responsibility for safety. Dr. Dickinson suggested that drivers who violate good driving rules by dangerously cutting in, making turns too fast, driving in wrong lanes, disregarding safety signals, having to apply their brakes to viciously, to avoid accidents, and those who are just plain bad drivers should be admonished by a courteous letter for earlier violations and that later their records should be turned over to the authorities for more drastic action if they persist in dangerous driving.

Among those participating in the discussion of Dr. Dickinson's paper were E. D. Merrill, president, Washington Transit Co.; Dr. F. A. Moss, psychologist; William A. Van Duzer, director of vehicles and traffic, District of Columbia; M. O. Eldridge, assistant director of vehicles and traffic, District of Columbia; W. O. Wheary, director of safety, W.P.A.; Lowell Mellett, editor, Washington *Daily News*; Burton W. Marsh, safety and traffic engineer, American Automobile Association; and Everett C. Scott, fleet operator.

Before the meeting, 18 attended a dinner in honor of the speakers.

Society Will Cooperate On Inspection Standards

Action was taken by the Council at its Nov. 4 meeting looking toward maximum cooperation from a technical standpoint with the project on "Standards for Inspection of Motor-Vehicles" now being undertaken by the American Standards Association.

Emphasizing the belief that the S.A.E. can function most effectively by supplying, through its technical committees, factual data and recommendations for rational handling of the projects involved, the Council decided to decline active sponsorship of this particular project.

The other groups invited to be co-sponsors for this project are the American Association of State Motor-Vehicle Administrators and the National Bureau of Casualty and Surety Underwriters. The object of the project is to draft standards, with the cooperation of all interested groups, that will serve as a basis for state regulations for motor-vehicle inspection, designed to lower the number of accidents resulting from vehicular defects.

The Council's report of the action is as follows:

"Upon motion, duly seconded, and in accord with Executive Committee recommendations, the Council voted to reaffirm and make known the Society's eagerness to cooperate in a technical capacity, contributing to the strictly engineering phases of this project as they may develop; further to make it understood that the Society, through its technical committees, is willing to supply factual data and recommendations aimed toward a rational and intelligent handling of the problems which this project involves; further, with the belief that the Society can be most effective on the basis outlined above and most helpful to other interested organizations and the public at large, by operating exclusively within the boundaries of engineering activity, the Council voted to decline co-sponsorship of this project."

Anniversary of X-ray Discovery Celebrated

• Indiana

Commemorating the fortieth anniversary of the discovery of X-rays 200 members and guests of the Indiana Section attended the Nov. 4 meeting at the Athenaeum, Indianapolis, at which Prof. George L. Clark, University of Illinois, spoke on "The Modern Science of X-ray of Metals," and R. Notvest, engineer, welding department, J. D. Adams Manufacturing Co., talked on "Production Problems in the Use of X-ray."

Professor Clark gave a rapid review of the various stages of X-ray advancement from its discovery to the present, illustrating his talk with numerous slides. He told how the art of manufacturing aluminum alloy propeller blades has been advanced through the use of X-ray research by examination of propellers after use and noting the changes that take place in the structure. A series of slides illustrated recent discoveries in the storage battery field through use of X-ray which are expected to lead to the manufacture of more dependable batteries. He also listed many advances in alloys that can be traced to X-ray research.

Mr. Notvest told of the great care necessary in the production use of X-ray and explained the use of X-ray in the examination of welds as conducted by his company.

Use Demonstrations In Service Talks

• Colorado

Using elaborate equipment for demonstrations in connection with their subjects, D. C. Donohoo, sales representative, and Jack Dickerson, power prover supervisor, Empire Oil and Refining Co. of Tulsa, spoke on "Carbon Monoxide Gases" and "Tuning of Motors for Correction" before 65 members and guests of the S.A.E. Club of Colorado at the Public Service Co. garage, Denver, Nov. 5.

During the business part of the meeting M. Merrill was elected president and Fred Eberhardt secretary-treasurer for the ensuing year. The club will have a booth at the Denver Automobile Show Dec. 2-7.

Ladies Honored by Dinner and Dance

• Oregon

Honoring the ladies, the Oregon Section held a dinner dance at the Lloyd Club on Nov. 9. More than 80 members and guests enjoyed a happy meeting.

During a short business meeting following the dinner J. Verne Savage was unanimously elected representative on the Sections Committee and it was voted to raise funds to send the section's representatives to the Annual Meeting in Detroit.

Applications Received

(*Continued from page 24*)

RUBBRA, ARTHUR ALEXANDER, designer, Rolls-Royce, Ltd., Derby, England.

RUSSELL, ROBERT PRICE, vice president and general manager, Standard Oil Development Co., New York City.

SCHWENDLER, WILLIAM T., chief engineer, Grumman Aircraft Engineering Corp., Farmingdale, L. I., N. Y.

SHERMAN, WILLIAM FRANCIS, technical data secretary, Chevrolet Motor Co., Detroit.

SHUMOVSKY, STANISLAV A., graduate student, Mass. Inst. of Technology, Cambridge, Mass.

SMITH, FRED LESTER, director of aeronautics, State of Ohio, Columbus, O.

STARNAMAN, SIDNEY C., service representative, Olds Motor Works, Lansing, Mich.

TAYLOR, PAUL L., president and general manager, Waverly Garage & Auto Engineering Corp., Newark, N. J.

WADMAN, REX W., editor, "Diesel Progress," Diesel Engines, Inc., New York City.

WAGNER, EUGENE L., owner, Gene Wagner, Denver, Colo.

WALDEN, JOSEPH W., engineer, Linde Air Products Co., Buffalo, N. Y.

WATSON, ERNEST ANSLEY, chief engineer, Joseph Lucas, Ltd., Birmingham, England.

WHITE, ANDREW J., proprietor, Universal Chemists & Brakestone & Thornton, Boston, Mass.

WHITTLE, WILLIAM SMITH, laboratory engineer, Chrysler Motor Corp., Highland Park, Mich.

YOUNGBERG, ERNEST G., sales manager, Shoreline Oil Co., Chicago, Ill.

Record Annual Meeting Forecast

PROMISING to surpass last year's record in attendance, interest and enthusiasm the 1936 Annual Meeting of the Society will be held at the Book-Cadillac Hotel, Detroit, Jan. 13-17. Sixteen discussion-provoking sessions are tentatively scheduled. Many of the speakers have been selected and the subjects of their papers agreed upon. It is too early to give dates for most sessions but it is certain that the dinner, always an important feature, will be held Thursday evening, Jan. 16, and the student session on Monday evening, Jan. 13.

A preview, like most previews—subject to change, will indicate the type of stimulating subjects planned by the various activities. All are timely and many of controversial nature should lead to enlightening discussions.

Aircraft Sessions

First Session

Paper—Engine Nacelles and Propellers, and Airplane Performance

Author—D. H. Wood, National Advisory Committee for Aeronautics

Second Session

Paper—Smart Airplanes for Dumb Pilots

Author—Prof. Otto Koppen, Massachusetts Institute of Technology

Paper—Every Man's Airplane, A Development Toward Simpler Flying

Author—F. E. Weick, National Advisory Committee for Aeronautics

Aircraft-Engine Sessions

First Session

Paper—Aircraft-Engine Fuel Economy, from the Operator's Viewpoint

Author—E. T. Allen, Pan American Grace Airways, Inc.

Paper—Engine Possibilities, and Devices for Obtaining Best Fuel Economy

Author—R. W. Young, Wright Aeronautical Corp.

Second Session

Paper—Eliminating Torsional Vibration in the Radial Aircraft Engine

Author—E. S. Taylor, Massachusetts Institute of Technology

Paper—Fuel Injection

Author—F. C. Mock, Bendix Products Corp.

Diesel-Engine Sessions

There are two sessions outlined by the Diesel Engine Activity, one on cooling and one, a joint session with the Fuels and Lubricants Activity, on Diesel fuel rating. The programs are not yet complete but it has been announced that one of the papers will be on Cetane Rating and Diesel Fuels jointly prepared by Dr. P. H. Schweitzer and T. B. Hetzel of Pennsylvania State College.

Passenger-Car Sessions

First Session (Chassis)

Paper—Suspensions

Author—W. R. Griswold, Packard Motor Car Co.

(Another paper is scheduled but has not definitely been selected.)

Second Session (Engines)

Paper—Fuel Consumption

Author—Alex Taub, Chevrolet Motor Co.

Paper—Engine Roughness

Author—P. M. Heldt, *Automotive Industries*

Third Session—Future Car Symposium

Speakers—Herbert Chase, consulting engineer; Amos Northup, Murray Corp. of America; W. B. Stout, Stout Engineering Laboratories, Inc.; W. D. Teague, New York City; John Tjaarda, Briggs Manufacturing Co.; and Austin Wolf, consulting engineer.

Joint Passenger-Car and Fuels and Lubricants Session

Paper—A Thermodynamic Study of the Effects of Volume Distribution of the Combustion Chamber Upon Engine Performance

Author—Prof. R. L. Sweigert, Georgia School of Technology

Paper—Relation of Exhaust Gas Composition to Air-Fuel Ratio

Authors—W. G. Lovell and B. A. D'Alleva, Research Division, General Motors Corp.

Passenger-Car Body Session

Paper—On Body and Chassis Design of Rear-Engined Cars

Author—L. Johnston, Stout Engineering Laboratories, Inc.

Production Session

Paper—The Place of Die Casting in Automotive Design

Author—J. C. Fox, Doehler Die Casting Co.

Paper—Economics of Planning and Scheduling for Motor Car Production

Author—V. P. Rumely, Hudson Motor Car Co.

Paper—Relation of Metallurgy and Production Methods in the Manufacture of Silent Transmission Gears

Author—R. B. Schenck, Buick Motor Co.

General Session

Several of the Activities are cooperating in the program for the General Session, the Topic for which is "Cylinder and Piston Ring Wear." The titles and authors of two of the papers are:

Paper—Cylinder Wear—Where and Why

Authors—S. W. Sparrow and T. A. Scherger, Studebaker Corp.

Paper—Effect of Gas Pressure on Piston Friction

Author—Morris P. Taylor

Transportation and Maintenance Session

The Transportation and Maintenance Activity has not, as yet, announced the subjects or the authors of papers to be presented at this session.

Truck, Bus and Railcar Session

The Truck, Bus and Railcar Activity has not, as yet, announced the subjects or the authors of papers to be discussed at this session.

Fuels and Service

W. S. Crowell, secretary **A. G. Marshall, vice-chairman** **J. F. Long, chairman**

These three officers of the Northern California Section spent many hours in conferences such as the one pictured here during the process of developing the successful Pacific Coast Regional Meeting held in San Francisco, Nov. 18-19.

FOUR Pacific Coast sections were hosts to the first Pacific Regional Meeting of the Society held in San Francisco, Nov. 18 and 19. Attendance was approximately 250. Ten papers, prolonged discussions and two highly interesting field excursions completed an ambitious program sponsored by A. G. Marshall, assistant superintendent of Shell Oil Company's Martinez refinery, and Col. William H. Fairbanks, motor vehicle superintendent of Southern California Telephone Co.

For an entire afternoon the group was guest of C. G. A. Rosen, chief research engineer of Caterpillar Tractor Co., San Leandro. Following the showing of two interesting Caterpillar films, the guests were divided into groups of 50 and systematically routed through the model plant at San Leandro. Every aspect of the company's research facilities was explained by members of Caterpillar's personnel. Mr. Rosen had moved a number of interesting testing units from the laboratories into a central display lobby where work was carried on and explained to the S.A.E. members.

Practically all of the company's research work is concentrated at the San Leandro plant; also all Diesel injection units are made at this plant. The extremely close tolerances to which Caterpillar injectors are held provided ample material for study, not only as to production and testing methods but also as to research programs connected with Diesel injection problems.

The first paper of the meeting was presented by P. W. Ensign, Ensign Carburetor Co., Ltd., the subject being "Butane Application and Performance in Automotive Service." The author pointed out that his company had had practical field experience with butane in 10 western states and under temperature conditions ranging from —10 deg. fahr. to 118 deg. fahr. He mentioned the growing popularity of butane with commercial operators, citing figures to show that approximately 6,000,000 gal. of butane were used in California vehicles during 1934 and that, for 1935, it is estimated gallonage will reach 8,000,000.

Touching briefly on the air-fuel ratio most desirable for butane, Mr. Ensign said that his experience favored 14 to 1. He mentioned that two of the chief obstacles to more satisfactory butane operation are the relative inadequacy of ignition systems and the inability to take advantage of the compression ratios that butane of 100 octane rating can carry.

Speaking briefly of the design of the Ensign carburetor for butane, Mr. Ensign described the various units and pointed out that on the type where either gasoline or butane can be used, it is necessary to have a float lock for the gasoline carburetor float in order to avoid float bounce and subsequent damage.

In the discussion that followed, G. L. Holzapfel, Holzapfel Instrument Co., denied the need for a float locking mechanism, his statement being premised upon the belief that bouncing of a relatively light carburetor float would not damage either the float or the actuating mechanism. Mr.

Featured at Pacific Coast Meeting

Holzapfel also took issue with the statement that California butane had an octane rating of 100. He said this was important because operators were inclined to complain of detonation when they were under the impression that the octane number was 100, when in truth it was only 93. The point was not settled one way or the other, although in informal discussion with oil men after the meeting it was learned that most California butane brands have a rating of 93.

Other points brought out by Mr. Holzapfel were:

(1) He has successfully used leaner mixtures than 14 to 1.

(2) That the bad name given butane in some quarters was due principally to poor installations made by inexperienced men.

(3) That butane, in most instances, gives as good mileage as gasoline. Also that large bore engines are most favorable for butane.

Dr. Ulric Bray, Union Oil Co., submitted the opinion that under wide open throttle conditions butane is likely to be less efficient than gasoline, while under partial throttle butane can, under many circumstances, be considered more efficient.

Carl Abel, Ethyl Gasoline Corp., asked Mr. Holzapfel if any data were available showing a comparison between Ethyl gasoline and butane in the matter of mileage. Mr. Abel stated that the only comparisons he had seen were those made with gasolines of about 65 octane number. Mr. Holzapfel replied that he had made a test with a 1935 car having a 7 to 1 compression ratio and found a slightly better gas consumption record in favor of Ethyl. The difference, he said, was about 0.3 of a mile per gallon.

Davis Day, Richfield Oil Co., remarked that there was a field for both gasoline and butane but that butane had some inherent limitations from a safety standpoint. He observed rather pointedly that dynamite was safe when properly handled, but not many people knew how to handle it. Butane, while not so dangerous, was nevertheless far from the point where it could be used by the public at large with any degree of safety.

"We once had the theory," said Mr. Day, "that combustible gases that were not confined would not explode. So far as butane is concerned that theory has been exploded, because there are several instances on record where butane has caused severe explosions in unconfined quarters."

Second paper presented at the first morning session was read by John C. Leslie, acting division engineer for the Pacific division of Pan-American Airways, with headquarters at Alameda Airport, the home base for Pan-American's now famous "China Clipper."

Outlining the "Practical Gasoline and Oil Problems in Trans-Pacific Flying Operations", Mr. Leslie emphasized that the first concern of an airline operator, so far as financial success is concerned, is that of fuel costs. Economical consumption is not only reflected in the cost of fuel, but also the additional pay load that can be carried, a factor not generally important in the motor-vehicle field.

Mr. Leslie said that in laboratories aircraft engines had been run with a specific fuel consumption of 0.40. In practical operation Pan-American has been able to cruise long distances with a specific fuel consumption of 0.48. Mr. Leslie emphasized that there is an immediate need for an engine or fuel, or combination of the two, that can reduce the consumption at cruising to 0.42. He said smilingly, "That reduction, gentlemen, would be very welcome to us if any of you men present can deliver it."

His company's experience, said Mr. Leslie, tended to show that highly leaded fuels were injurious to their equipment. The company specifications call for fuels not leaded more than 3 cc. per gal. Stability of fuel is particularly essential for Pan-American operations. Fuels are sometimes stored for several months on the Mid-Pacific island bases and are exposed to sharp changes in temperature. Any tendency to gum, said Mr. Leslie, is decidedly dangerous. He also pointed out that the ground personnel is trained very thoroughly in the matter of handling fuel and checking it before fueling planes.

"We need," Mr. Leslie remarked, "a better measuring stick than 'practical experience' in the matter of purchasing lubricating oils." Practical experience, he stated, is too slow and too costly, and sometimes dangerous. He pointed out that corrosive action or excessive sludge formation is very costly on a ship like the China Clipper. With 56 cylinders to remove, in the event of trouble caused by oil, the repair cost is quite obvious. Ring sticking on the high output engines of the type used by the China Clipper is somewhat of a problem.

In the discussion that followed, G. L. Neely, Standard Oil Co. of Calif., asked the ratio of oil to gasoline consumption on the China Clipper. Mr. Leslie replied that normal gasoline consumption was 130 gal. per hr. and oil about 8 gal. per hr.

Mr. Moore, Union Oil Co., inquired about the gum formation in gasoline and asked if the gums actually caused trouble. Mr. Leslie replied that he had only had one personal experience with gum and in this case the various gasoline screens were clogged by a gelatinous substance.

J. F. Long, J. F. Long Co., pointed out that from his experience in maintaining privately-owned airplanes he found

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THE field excursion on the second day was limited to 100 men who wished to see the San Francisco-Oakland Bay Bridge at close quarters.

Arrangements were made by Mr. Maynard of Shell Oil Company for the visitors to be taken to Goat Island, where Chief Engineer Purcell of the Bay Bridge was host.

Members from the East and others who were not Northern California residents were given preference.

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it advisable to recommend much lighter oils than were usually recommended by the engine manufacturers. He said that he had several cases where engines would not run more than 200 hr. before a top overhaul and that by reducing the oil viscosity it was possible to obtain from 300 to 500 hr. satisfactory operation before any overhaul was necessary. He emphasized the fact that a top overhaul is a relatively expensive operation and that if it is possible to run the engine 500 hr., and then give it a major overhaul, the cost to the owner would be much less.

Operating Diesel Fleets

C. T. Anthony's "Diesel Fleet Operation and Maintenance Problems" was a most specific paper. Pointing out that lower and lower railway freight rates are forcing truck haulers to closer and closer operating margins, Mr. Anthony said that his company purchased Diesel equipment with a prayer and hope. With over 100 Diesel-equipped trucks now in service, Mr. Anthony said, the equipment has completely changed the company's financial condition—Diesels absolutely put them "in the black".

Averaging 202 miles per day, the Diesel trucks maintain a comprehensive store-door to store-door service in competition with railroads. Mr. Anthony, to definitely establish Diesel economy, purchased 10 new six-wheel gasoline-powered trucks and 10 Diesel-powered trucks of the same make and capacity. Operating over the same routes, the following data were established:

	Gasoline	Diesel
Miles per gallon of oil	160	144
Miles per gallon of fuel	3.7	6.01
Maintenance cost per mile (repair labor and motor parts only)	1.7 cents	2.1 cents

The net advantage of Diesels over gasoline after considering all operating costs, depreciation, insurance, interest, etc., was found to be $25,270 per million truck miles. Since the company operates about 4,500,000 miles per year the saving is quite obvious. Stated in terms of percentage Mr. Anthony said that the Diesels saved them 27.8 per cent.

Another advantage of the Diesels is the time saving on runs. Mr. Anthony observed that on a 200-mile run over highways that were partially mountainous it was common for the Diesels to save from one to one and one-half hours of running time, due to their greater lugging ability on grades, the drivers often running from one to two transmission speeds higher than is possible with gasoline trucks.

Substantiating the above figures Mr. Anthony mentioned another comparative test of the same nature which involved 2,400,000 miles of travel. The difference between the first and second tests was only $620; a remarkably close check.

In discussion, Colonel Fairbanks asked if Pacific Freight Line trucks were "installation" jobs or factory built. Mr. Anthony replied that they had both types of equipment but that in his opinion there was no advantage of one over the other. He said that European experience had demonstrated the accuracy of this premise.

The higher maintenance cost of Diesels is due in a large part, according to Mr. Anthony, to the relatively high cost of parts. Actual mechanical work by regular mechanics does not offer any particular problems or additional expense.

J. M. Evans warned that people should not be too optimistic about the future of Diesel fuel. He said that crude yields about 30 per cent gasoline and only 5 per cent Diesel fuel. Mr. Anthony replied that Diesel fuel would have to increase 390 per cent before the cost of operation would equal that of gasoline-propelled equipment. He said it is almost a foregone conclusion that there would be some measurable increase in Diesel fuel from the standpoint of taxation alone.

C. A. Winslow requested an explanation as to the manner in which the comparative costs were computed, particularly facts concerning the write-off due to depreciation. The author replied that in the comparative cost computations all of the equipment was written off on a 200,000 mile basis; therefore the figures were strictly comparable.

Discussing fleet maintenance problems on the Pacific Coast, S. B. Shaw, Pacific Gas & Electric Co., brought out specific facts about fuel, lubrication, engine, chassis, body, and tire problems in the second paper at the Monday afternoon session. The detailed phases of his discussion were based on replies to a questionnaire sent to many Pacific Coast fleet operators.

Dividing the method by which maintenance is provided into two classes, fleet-shop and outside-shop maintenance, Mr. Shaw pointed out that those fleets with high density as measured by vehicles per square mile of territory commonly operate their own service shops.

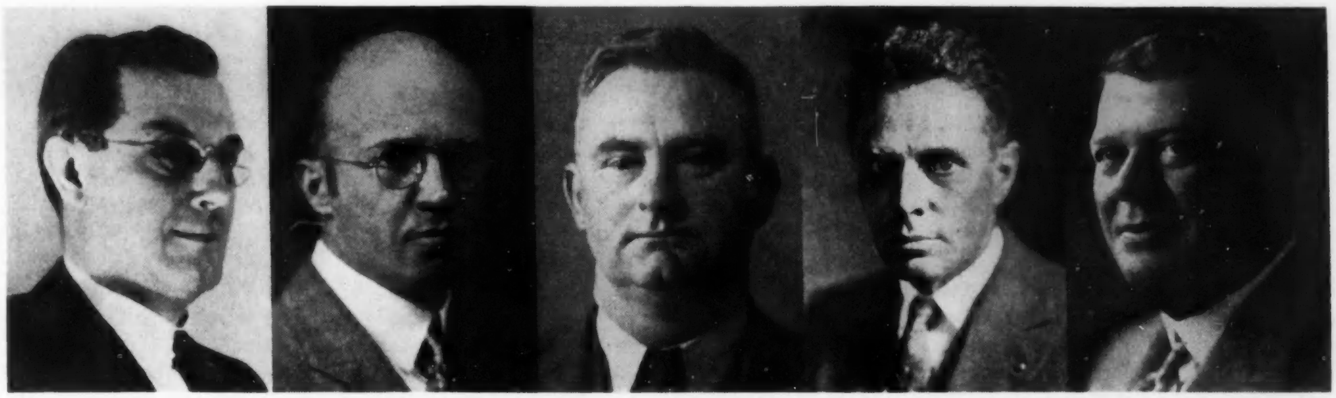
Usually, maintenance work is decentralized, he said, distances between shops varying from 20 to 500 miles, again depending on the fleet density. He mentioned one fleet of nearly 2000 vehicles in an area approximately 100,000 square miles which operates shops where overhauling is done, besides an equal number where minor repairs and servicing are taken care of.

The greatest fuel problems facing Pacific Coast operators, Mr. Shaw stated, is that resulting from vapor lock. This difficulty is accentuated by the wide range of temperature conditions met with, sometimes in a single day's run, and is most frequent in the spring and early summer, especially when storage tanks are full of "winter" grade gasoline of high volatility and vapor pressure and the weather turns suddenly hot.

T. B. Rendel

His topic was Diesel fuel knock testing

Some of the Speakers at the Two-Day Meeting



R. S. Burnett *Told Standards Story* | **C. G. A. Rosen** *Talked on Diesel Injection* | **S. B. Shaw** *Discussed Maintenance* | **C. B. Veal** *"Cooperation Research Keystone"* | **W. H. Fairbanks** *Chairman at T & M Session*

Minimum trouble is experienced from sludging of crankcase oil, Mr. Shaw said, and little from gear lubricants except for a few operators who report "foaming". Modern design of universal joints and other parts formerly difficult to lubricate, together with provision of modern greases, have reduced chassis lubrication problems to a minimum, he said, while the task of equipping shops with special tools needed for servicing new models is not as great as might be expected.

Considerable difficulty has been experienced with parts service, Mr. Shaw's investigation showed. He suggested also that much improvement might be made in truck design from the standpoint of accessibility for easier maintenance.

Operators seem inclined to criticize ignition equipment, Mr. Shaw stated. The principal faults found in lighting systems, he listed as "poor driving light, poor wiring and poor connections." The cooling system also is open to improvement, he said, and steering gears should be better adapted to low-pressure tires and easier steering, in the opinion of many of the operators contacted. Brakes came in for considerable criticism from the operators who answered the questionnaire, short life, tendency of drums to get out of round and sluggish response by some parts of the mechanism being mentioned prominently.

Units discussed by Mr. Shaw which seemed relatively satisfactory to most of the operators contacted included, in addition to those already mentioned, carburetors, air cleaners, clutches, axles, and tires.

Despite his discussion of weak points in modern vehicles, Mr. Shaw emphasized strongly the fact that "great credit is due to those who have done such excellent work in overcoming the difficulties that have arisen in the last few years."

In connection with a remark of Mr. Shaw's concerning batteries, Tom Dooling asked in discussion whether battery deficiencies were noted on original or replacement equipment. Mr. Shaw replied that original battery equipment gave the trouble. A representative of the Seattle Motor Coach Co. volunteered the information that his company had found it necessary to have a dual battery and generator system. Julius Brunton replied that his experience had been similar, that he had installed dual units on many police cars and other equipment where the battery drain was heavy. He observed that battery equipment in the average truck was little better than that installed in a passenger car.

A representative of Rio Grande Oil Co. asked Mr. Shaw if he had noticed any increase in foaming of transmission gear oil when lubricants were mixed. Mr. Shaw replied that he had no data on the subject.

The session on Thursday morning was devoted to fuel and lubricant questions, two of the papers dealing with knock-testing and the third with testing of extreme pressure lubricants.

Knock-Testing Diesel Fuels

T. B. Rendel, Shell Petroleum Corp., who is nominee for S.A.E. vice-president representing the Fuels and Lubricant Activity next year, dealt with knock-testing of Diesel Fuels, beginning with the assertion that "Diesel engines as we know them today are really still in their infancy."

During the last few years, he said, there has been a marked tendency toward increasing the speed of the Diesel engine—so much so that the Diesel is now able to compete with the gasoline engine in road transport work. This has brought to the fore the phenomenon known as "Diesel Knock" and also the fact that the newer, faster Diesel engines are more sensitive to fuel changes than their more elderly cousins.

Mr. Rendel outlined the mechanism of combustion in the solid-injection high-speed compression-ignition engine as taking place in three stages, starting from the commencement of injection as, (*a*) a delay period during which no appreciable combustion takes place and the fuel is heated up to its ignition point; (*b*) the rapid burning of fuel which has been injected during the delay period; and (*c*) the instantaneous ignition of the remainder of the fuel as it enters the flaming gases in the fuel-injection valve. He stated that minimization of the duration of the delay period is essential to give proper control of fuel combustion and hence control of knocking and engine weight.

The two ways in which the delay period can be reduced are either by employing very high compression ratios which, however, increase the maximum pressure; or by providing some suitably located hot surface in the combustion chamber to promote ignition. He added that the ignition quality of fuel, however, can, and in some engines does, play an important part in the reduction of this delay period although the extent of this depends entirely upon the design of the engine.

The importance of the ignition quality of fuel in controlling the delay period and hence the knocking of the

engine has been recognized and measurements of the ignition quality in the fuel have become the subject of considerable investigation. Mr. Rendel told of the work of the C. I. Fuel Research Committee in developing methods of measuring ignition quality of fuel and the development of "cetane numbers" in fuel rating.

He continued by stating that the two most common methods of test using actual engines have numerous advantages, but that a special design of engine is necessary to obtain best results. Experiments were therefore started on a C.F.R. engine suitably modified so as to measure accurately delay periods and to obtain clean combustion at all times. He explained how this had been accomplished by redesigning the entire cylinder and cylinder head in the light of the best available knowledge of combustion-chamber design.

With this engine it is possible to use both the critical-compression method of rating fuels described by Messrs. Pope and Murdock and also, in conjunction with a modified bouncing-pin, the delay method suggested by Messrs. Boerlage and Broeze, and to obtain measurements of the ignition quality of a Diesel fuel with reasonable accuracy and with a minimum amount of engine maintenance.

Knock Testing Argued

Discussing Mr. Rendel's paper, C. C. Moore, Jr., Union Oil Co. of Calif., pointed out that the "delay period" and detonation in compression ignition engines is a *time* factor. For this reason, when considering high-speed Diesel engines, the ignition delay, although of no greater duration on a time basis, covers a greater number of degrees of crank revolution and therefore becomes a greater proportion of that part of the cycle which is available for combustion. This was believed by Mr. Moore to be the fundamental difference between low and high-speed Diesel engines as regards fuel requirements. Mr. Moore described tests in a three-cylinder commercial engine in which the detonation was so severe, because of poor ignition quality of the fuel, that it was necessary to terminate the test in order to prevent destruction of the engine.

Questioned as to the cetene number requirements of the Cummins engine, Mr. Rendel answered that operating conditions caused large variations in the fuel required but in general above a 35 to 40 cetane number fuel no difference in operation attributable to ignition quality of the fuel could be observed.

G. R. Kaye, Union Oil Co. of Calif., asked if consideration had been given by the C.F.R. C.I. Volunteer Group to the influence of fuel viscosity on the performance of the fuel injection system and the resultant influence on the rating of fuels in the C.F.R. engine.

Mr. Kaye pointed out that fuels identical in actual ignition quality, but differing widely in viscosity, may appear to have different cetene numbers when rated in the present C.F.R. engine. Mr. Rendel replied that this effect had been considered as evidenced by the removal of the timer from the pump unit so that adjustment of the fuel pump for different fuels could be made without disturbing the setting of the timer.

Dr. D. R. Merill, Union Oil Co. of Calif., discussed the subject of cooperation between laboratories not members of the C. I. Volunteer Group and this group on problems of mutual interest.

Chairman J. R. MacGregor explained the difference between cetene and cetane numbers and expressed the opinion that less confusion would exist if cetene numbers were no longer referred to in current test work and fuel specifications; cetane number being the preferable designation. It was shown that the early stocks of the primary reference fuel cetene obtained from various sources were of questionable purity and ignition quality. As a result, cetane of known purity and knock-rating, has become the generally accepted primary standard.

At this session, gasoline knock-testing was the topic of the second paper. It was presented by C. F. Becker, Associated Oil Co., who commended the Cooperative Fuel Research Committee for the wonderful advancement that has been made in the art of gasoline antiknock testing over a period of years.

"Through their efforts," he stated, "the equipment and testing procedure has made possible results which in most instances are quite consistent and valuable."

With the present procedure and equipment for determining octane rating numbers, however, there are periods when consistent operation is difficult and results unreliable, according to Mr. Becker.

Based on a survey among operators of C.F.R. equipment on the Pacific Coast, Mr. Becker announced the consensus of opinion as being that, basically, the C.F.R. engine is a satisfactory apparatus for determining octane numbers. Some laboratories, however, expressed the opinion that more accurate and consistent results may be obtained by (*a*) continued refinement of engine and instrumentation; (*b*) establishment of a more precise test procedure; and (*c*) universal adoption of standardized reference fuels.

Regarding fuels, the Pacific Coast survey shows that a large number of reference fuels are found in use and this undoubtedly is one of the causes of varying results experienced in correlation work.

Following Mr. Becker's paper, Mr. Moore stimulated a lively discussion on the subject of secondary reference fuels. The variety of secondary reference fuels used on the Pacific Coast was commented upon. Mr. Moore stated that calibration of Standard Oil Development Co.'s A and C reference fuels on certain of their engines did not agree with the published calibration curve. However, using this reference fuel and the calibration curve obtained by direct comparison with octane and heptane on the particular engine, results were obtained on check sample which agreed very closely with other laboratories when testing the same check fuels. Since a secondary reference fuel calibration curve was required on each individual engine and the published curve could not be used, there was not much point in buying such secondary reference fuel at a price ten times as great as uncalibrated fuels of similar type.

No reason for the discrepancies reported by the various laboratories when calibrating these secondary standard fuels was advanced but similar experience was indicated by the representatives of the other oil companies present.

In response to a request from the Chairman, W. V. Hanley, Standard Oil Co. of Calif., advanced an explanation for the discrepancies in calibrating secondary reference fuels against octane and heptane. It was pointed out that octane and heptane are more pressure sensitive than the common fuels so that compression pressures deviating as much as a few pounds from the average compression pressure of all laboratories will result in differences in secondary reference fuel calibrations and knock ratings. This was found to be true on the Army Air Corps engine using the temperature plug, so that the effect cannot be attributed to the bouncing pin although it can be minimized by the proper pin setting.

Tests in the C.F.R. engine were described in which a

range of compression pressures at standard knock equivalent to that normally covered by laboratories in calibrating secondary reference fuels, was employed. This resulted in errors in calibration of the magnitude mentioned by Mr. Moore.

Mr. Hanley recommended that consideration be given to the use of a compression pressure of 98.0 ± 0.5 lb. per sq. in. at standard knock (average of a number of laboratories) with a calibrated pressure gage without regard to compression ratio. It was stated that by this method excellent agreement on calibration curves and fuel ratings had been obtained.

An improved bouncing pin was described by R. V. Clark, Shell Oil Co. of Calif., which eliminated the necessity of employing bushings to support the pin.

Concluding the Tuesday morning session, G. L. Neely, Standard Oil Co. of Calif., presented his paper, "Extreme-Pressure Lubricants Testing." In it he described briefly why extreme-pressure lubricants are necessary and what machines have most commonly been used to evaluate them.

The need for extreme-pressure lubricants, he said, has arisen because of the development of new types of metals which are very much higher in tensile strength than were the best steels available several years ago, and the development of faster and more powerful engines, has resulted in a great increase in the unit loading of the oil film on the gear teeth of modern cars. Another reason for the development of extreme-pressure lubricants has arisen through the development of hypoid gears adding a high rubbing speed of one gear tooth against another at high unit loading.

He showed that results vary considerably in the tests of extreme-pressure lubricants for the purpose of evaluating them, carried on by the S.A.E. Subcommittee on Extreme-Pressure Lubricants in cooperation with the National Bureau of Standards on the types of machines that had been built for that purpose. He gave some examples of actual differences resulting from these tests.

In view of the difficulties of correlation with the machines examined by the National Bureau of Standards, the Bureau, acting under the sponsorship of the S.A.E. Subcommittee, designed and built the first model of the S.A.E. Extreme-Pressure Lubricants Tester. This machine has been subsequently redesigned and improved. He described this machine and pointed out the advantages. He concluded by stating that in view of the contradictory results obtained in the other machines, that such contradictions might be obtained with the S.A.E. Tester. The problem of correlating laboratory data with service data will be simplified by the use of this machine.

Dr. Bridgeman, National Bureau of Standards, said in discussion that he does not exactly agree with Mr. Neely in that he considers load-carrying capacity the most important characteristic of an extreme-pressure lubricant. He stated, however, that he feels that friction reducing value and stability are of primary importance in these lubricants and that there is a wide difference in the extreme-pressure lubricants which he had tested as regards these properties. As an example he mentioned that as much as 200 deg. fahr. difference in operating temperature had been found for different commercial gear oils which very markedly influenced the stabilities of these lubricants in service.

The Bureau has found no one of the four extreme-pressure lubricant testing machines previously tested to be entirely satisfactory, Dr. Bridgeman reiterated. Any one of these machines could be used to rate a number of lubricants in the order of their true service values, but no one of them would properly rate all of the lubricants tested. He stated that the information so far obtained with the new S.A.E. Tester indicated that this machine would properly rate extreme-pressure lubricants but that absence of adequate service data and adequate test data from the machine prevented him from making a definite statement at the present time.

A question was asked as to whether or not the worm gear machine described in the paper was usable for obtaining stability data.

Col. Fairbanks of the Southern California Telephone and Telegraph Co., stated that his company was using castor oil for lubricating the gear sets of the heaviest trucks made in the most severe service.

In reply to the discussers Mr. Neely stated that he was sure that Dr. Bridgeman and he were in virtual agreement as to the importance of the different properties of extreme-pressure lubricants in general. As a chain is no stronger than its weakest link, an extreme-pressure lubricant is no better than the poorest of its important properties and an adequate extreme-pressure lubricant must be satisfactory in all regards.

Mr. Neely said that the worm gear machine described in his paper is an excellent mechanism for determining the stability properties of gear oils. He stated that under the conditions of load imposed on this machine that the bronze gear was caused to wear and that small pieces of bronze were distributed throughout the oil where they acted as oxidation catalysts in a manner very similar to actual service.

In regard to Col. Fairbanks, Mr. Neely said that while castor oil may be believed to have excellent lubricating properties, that the worm gear machine and other oxidation testing devices had shown it very unsatisfactory.

Dinner Closes Meeting

Speaking at the big dinner which closed this highly successful gathering on Tuesday, Nov. 19, C. B. Veal, manager of the research department, and R. S. Burnett, manager of the standards department of the S.A.E., told of the purposes and plans of these two important branches of the Society.

Automotive research activities moved ahead fast during the lean years of the depression, Mr. Veal said.

Although lacking in funds during that period, he pointed out, manufacturers did have ample laboratories and trained engineers, both of which were utilized actively during the 1930-1934 lull in automotive production. Through this development, the research work of the Society of Automotive Engineers has been accelerated into its third stage—that of cooperative experimental investigation. The first stage, begun in 1921, he described as that of accumulation and dissemination of technical information; the second, coming a few

G. L. Neely
Talked Lubricant Testing

John C. Leslie
Trans-Pacific Flying

years later, involved formulation of programs and designation of impartial research laboratories to carry them out.

Development of instruments for measurement of riding comfort in automobiles was one of the research projects described by Mr. Veal which bears directly on the improvement of automobiles for everyday use. Formulation of basic definitions of wheel alignment elements is another effort in this same direction as is the work which is going forward in checking the reproducibility of results obtained through the Cooperative Fuel Research Committee's laboratory method of obtaining knock ratings for motor fuels and in developing standard procedure for vapor lock tests.

Touching on currently important projects, in the lubrication field, Mr. Veal mentioned tests to determine whether or not engine wear can be reduced by adding oiliness agents to oil; comparison of results obtained by various methods of testing crankcase oil stability; and completion of a machine to measure the load-carrying capacity of extreme-pressure lubricants.

Ways to determine the knocking characteristics of aviation gasoline also are being studied.

Mr. Burnett showed that all kinds of industrial products now are using standards developed originally for automobiles by automotive engineers, citing numerous examples.

S.A.E. steel specifications, he pointed out, have very much simplified the making of steels and are being commonly used in the railroad, petroleum, marine, machine tool and many other industries. Automotive standards for fine pitch screw threads are used in practically all mechanical industries. The Society first began its standardization activities in 1910.

Complicating influences of legislation and regulation make standards relating to motor-vehicle operation difficult to formulate, according to Mr. Burnett, but, he said, operating standards have become an increasingly important part of the Society's work ever since 1931, when the first one was adopted. Frequently a research program is needed to obtain basic data on which to build standards affecting vehicle operation, since it is essential that the work be kept on an engineering basis, free from political or purely commercial influences.

Production cost reductions running into millions of dollars each year are achieved as a result of standardization activities, Mr. Burnett stated, pointing to one automobile maker who estimates savings of $52,000 per year through standardization of so minor an item as hexagon head screws. Standardization of nuts saves another manufacturer $500 per day. Reductions ranging from 20 to 30 per cent are commonly reported, he said.

A feature of this Pacific Regional Meeting was the excellence of the arrangements in general and the actual handling of the sessions by the various chairmen in particular.

At the opening Fuels Application session, J. M. Evans, Associated Oil Co., presided. C. G. A. Rosen, Caterpillar Tractor Co., handled the Monday afternoon inspection trip session, as previously mentioned, while William H. Fairbanks, Southern California Telephone Co., was in the chair at the Transportation and Maintenance Session on Monday evening.

Tuesday Chairmen were: J. R. MacGregor, Standard Oil Co. of Calif., at the Fuels and Lubricants Testing Session, and A. G. Marshall, Shell Oil Co., at the dinner meeting.

Meetings Calendar

S. A. E. Annual Meeting
Jan. 13-17, 1936
Book-Cadillac Hotel, Detroit

Baltimore—Dec. 5

Engineers Club; dinner 6:30 P. M. Subject—Lubrication.

Buffalo—Dec. 10

Hotel Statler; dinner 6:30 P. M. Boulder Dam Project—G. E. Gronemeyer, Babcock & Wilcox Co. Open House Night—Ladies invited.

Canadian—Dec. 18

Royal York Hotel, Toronto; dinner 7:00 P. M. Stresses and Strains of the Automobile Parts Business—Alexander Gray, president, treasurer, Gray Forgings and Stampings, Ltd. Past-Chairmen's Night.

Chicago—Dec. 3

Hamilton Club; dinner 6:30 P. M. Safety Symposium; speakers, J. F. Winchester, manager, General Automotive Division, Standard Oil Co. of New Jersey; Sidney J. Williams, director of public safety, National Safety Council; George W. Fleming, general secretary, "Keep Chicago Safe" Committee.

Cleveland—Dec. 9

Cleveland Club; 7:45 P. M. Modern Trends in the Automotive Field—Austin M. Wolf, automotive consultant.

Detroit—Dec. 16

Book-Cadillac Hotel; dinner 6:30 P. M. Manufacturing of Automotive Fabrics—H. C. Templeton, mill manager, American Woolen Mills.

Fabric Chemistry and Variables—H. D. Grimes, chemist, American Woolen Mills.

Indiana—Dec. 12

The Athenaeum, Indianapolis; dinner 6:30 P. M. Review of the Shows—Harold F. Blanchard, technical editor, *Motor*, and Lee Oldfield, consulting engineer.

Metropolitan—Dec. 9

The Roger Smith, 40 E. 41st St., New York City; dinner 6:30 P. M. Lubrication of the Engine—W. J. Cumming, general superintendent, Surface Transportation Corp. Lubrication of the Chassis—H. K. LaRowe, assistant purchasing agent, Dairymen's League Cooperative Association.

Milwaukee—Dec. 9

Falk Corporation plant, foot of N. 30th St.; meeting 7:30 P. M. Developments in Power Transmission Equipment, with Special Reference to the New Variable Speed Transmission—Louis A. Graham, vice-president, Falk Corp.

New England—Dec. 10

Walker Memorial, M. I. T., Cambridge, Mass.; dinner 6:30 P. M. Transportation and Maintenance Meeting; speaker, T. L. Preble, supervisor, automotive equipment, Tide Water Oil Co.

Northern California—Dec. 10

Athens Athletic Club, Oakland; dinner 6:30 P. M. Development of High-Performance and High-Powered Aircraft—W. B. Goodman, field engineer, Wright Aeronautical Corp. Contribution to Low-Cost and Low-Powered Aircraft Engines—Nat Price, consulting engineer, Universal Engine and Propellor Co.

Oregon—Dec. 7

Refining Industries plant, Portland. Methods and Significance of Lubricating Oil Tests—S. C. Schwarz, chief chemist, Portland Gas & Coke Co.

The Why and How of Modern Fuels—C. F. Olson, Jr.

Northwest—Dec. 7

Seattle, Wash.

Joint meeting with the Oregon Section.

Philadelphia—Dec. 11

Philadelphia Auto Trades Association, Inquirer Bldg.; dinner 6:30 P. M. When Is a Truck Tire Overloaded?—James E. Hale, manager, Development Department, Firestone Tire & Rubber Co.

Pittsburgh—No Meeting

Southern California—Dec. 4.

Mona Lisa Restaurant, Los Angeles; dinner 6:30 P. M. Fuels of the Future—Earl Bartholomew, director, Engineering Laboratories, Ethyl Gasoline Corp.

St. Louis—Dec. 13

Coronada Hotel; dinner 6:30 P. M. Subject—Carburetion, Vapor Lock, etc.

Washington—Dec. 2

University Club, Washington, D. C.; dinner 6:30 P. M. Subject—Maintenance.

Papers from Recent Meetings Digested

Metropolitan Regional Transportation & Maintenance Meeting Papers

Newark, N. J., Oct. 29 - Nov. 1

Service Problems—*O. M. Brede, director of service, General Motors Truck Co.*

THE paper centers attention on operating cost control, which is stated to be the most difficult of all the service problems to solve. Until the scientific as well as the mechanical phase of maintenance is recognized, until repairs are made from facts rather than guesswork, and until the question: Why this failure? takes precedence over "repairing," the author states that this serious service problem cannot be solved.

The danger of confusing cost records with maintenance factual information is emphasized. Only a maintenance history, a chronological array of facts embracing repairs, repeat work, road failures and the like, can answer the question: What caused this cost?

Preventive maintenance has as its fundamentals regularity, uniformity and thoroughness, and can be applied to any single vehicle or fleet regardless of whether self-maintenance or service-station maintenance is practised.

Numerous illustrations of maintenance troubles and forms for record purposes are given and commented upon. In conclusion, the author advocates the promulgation by the industry of a preventive-maintenance system.

Motor Vehicle Inspection—*James J. Shanley, chief inspector, Motor Vehicle Department, State of New Jersey.*

THE author notes that several States have motor-vehicle-inspection set-ups and furnish statistics listing hundreds of thousands of corrections of vehicles and equipment. Yet many of these same jurisdictions cannot point to any reduction in accident frequency directly attributable to the requiring of inspections. This seeming paradox can be readily understood upon analysis. Most accidents are due to actions of drivers and pedestrians and it is generally agreed that only a very, very small percentage of all accidents can be attributed to faulty and unlawful vehicles and equipment, although one authority holds that defective vehicles figure in 15 per cent of all *fatal* accidents. In view of this one can understand why jurisdictions having inspections may not be readily able to sift out possible inspection benefits from a steadily mounting accident toll.

In practice, the system of appointed official inspection stations has many shortcomings. There is a great lack of uniformity between stations both as to equipment and methods. Some of this is due to the shortage of supervisory personnel, but much more is due to the fact that political pressure often dictates the appointment of unfit stations and virtually protects them from discipline after they are appointed. Due to lack of uniformity and, more often, to personal considerations, vehicles which were rejected at one station are passed in exactly the same condition at another station. This breeds widespread public disrespect for motor-vehicle inspections.

Spring, Tire and Shock Absorber Testing Development—*S. Ward Widney, director of engineering, B. & J. Auto Spring Co.*

FOR many years engineers have been striving toward a clearer understanding of the three agencies, tires, springs and shock absorbers, whose main function it is to absorb road shocks. Various means have been devised in the way of testing equipment, but none has produced entirely satisfactory results.

The problem of road-shock absorption is solely one of dynamics, not one of statics. Statics concern the load-carrying phase only of the tires and springs; therefore, the problem, if it is to be solved, must be approached from the dynamic standpoint. Moreover, the combined action of tire, spring and shock absorber must be studied. To study each separately does not go far enough, since a given tire may possess superior qualities of its own but, when working with a given spring and shock absorber, the combined effect may be less desirable than if a tire of different construction or qualities were used. This may sound contrary to basic principles; but the author states: "we have proved it to be so." Much the same holds with the spring and shock absorber. Thus we must investigate not only the individual dynamic qualities of tires, springs and shock absorbers, but, of greater importance, we must ascertain their combined effect.

Numerous illustrations are used and commented upon in presenting the various phases of the subject, and the author states that, "with a device termed the Ride-O-Graph, we have made progress toward establishing a definite and reliable test which shows the comparative effectiveness of tires, springs and shock absorbers."

The Operation and Engineering Problems of the Injection Engine—*T. R. Kelley, Diesel field engineer, Waukesha Motor Co.*

NOW that it is possible as well as practical to build a high-speed light-weight Diesel engine, other factors must be considered and these are enumerated. The results of 10 years of Diesel development by Harry R. Ricardo, of England, and the Waukesha Motor Co., with special reference to the Comet type of Diesel, are commented upon.

Features of the manufacturing materials used are specified, operating efficiency is exemplified, and the fuel system is described. The specifications for the most desirable fuel for this engine are stated.

Other subjects discussed include suitable lubricating oils and filters, water temperature, and piston rings.

It is stated that the Comet type of Diesel, provided that it is adjusted properly, operates with invisible exhaust at all loads and speeds within its operating range from 500 r.p.m. to governed speed.

General Transportation Meeting Papers—Chicago, Oct. 10

When Is a Truck Tire Overloaded?—*J. E. Hale, Firestone Tire & Rubber Co.*

LENGTHY consideration is given to tire overloading, with the understanding that overloading as referred to in tire failures is quite different from the application of the term "overload" to structural materials which collapse under a reasonably well-defined excess of load.

While this paper deals primarily with overloading, there are so many other aspects relating to the use of truck-bus tires affecting the industry that a discussion is included of various other phases of the tire business intended to be instructive along the line of longer life and greater freedom from trouble.

The increasing varieties of service in which motor vehicles are being placed demand different types and characteristics of tires, which are outlined. Then there is a discussion of the relative merits of the balloon type versus high-pressure-type tires.

The choice of tires for new trucks and buses is covered in a practical way and also there is a section outlining the variations of the basis for determining loads and air-pressure recommendations.

For the truck operator's benefit, there is included a section as to what the operators should know and practice to get the most out of tires, discussing the importance of inflation, dual mating, wheel alignment, repairs, and retreading on both tires and inner tubes.

The Economical Loading and Operation of Motor Trucks—*A. J. Scaife, White Motor Co.*

MANY organizations and individuals have been trying to get a simple formula for measuring the economy of motor trucking from a load-carrying standpoint; that is to say, is it more economical to buy a low-priced truck, load it to the limit for a few thousand miles, discard it and buy a new one, instead of buying a higher-priced truck, and run it three or four times farther, even up to the point of obsolescence, before buying a new one?

To make an intelligent analysis, it is well to consider first the type of truck that should be used to do the work required in the most efficient manner and then compare it with a vehicle that will do the work after a fashion. In making a study of this subject, we often find that all the factors have not been taken into consideration.

When actual operating records are compared in the same organization, doing the same kind of work, the results are most interesting. And it is easy to see that it is poor economy to buy a motor truck and operate it out of its class by overloading, not only from an economic standpoint, but also from a safety and highway-hazard standpoint. Failure on the highway, loss of time, delay in delivery, and the like, are all factors that should be considered.

General Tractor Meeting Papers—Chicago, Oct. 11 & 12

Research and the Motor Car—*T. A. Boyd, Research Division, General Motors Corp.*

THIS paper is essentially a technical history of the motor car, a history written from the viewpoint of the paramount part which research has played in the rapid evolution of the automobile.

Recognizing the similarity between the tractor and the automobile in respect to technical needs, the paper proceeds to show, first, that it was research which gave us the automobile in the beginning; second, that all of the improvements in cars were made through research; third, that continued improvement demands a consistent continuation of research; and fourth, that, as the car itself has got better and better, the kind of effort needed to improve it still further has had to be advanced from the elementary form of experimentation employed in the early days to include more and more of the original or the pioneering form of research.

The nature and the extensiveness of the facilities available for research within the automobile industry, and within those many industries which furnish the materials that the automobile is made of, are illustrated, and some of the specific advances in knowledge which are needed for the further improvement of the automobile are enumerated.

Just as research has been responsible for the marvelous advancement of the automobile up to now, so the further use of research is to make sure that the future of the motor car will be as glorious as its past. Right from the beginning, forward-looking automobile men have believed in research and made use of its products. They have not been like the atheist who quit being an atheist because, as he said, there is no future to it.

Some Factors Affecting the Performance of Tractor Gears—*H. W. McQuaid, Republic Steel Corp.*

IT is emphasized that tractor gear design and tractor gear service do not differ fundamentally from automotive truck, bus or any heavy duty gear application.

Due to errors in cutting, distortion in heat treatment, or deflection under load, the ideal rolling contact of gears is seldom realized when the loads are heavy, so that, in practically all heavily loaded gears, not only stresses due to the rolling contact but abrasive action due to sliding contact occur.

It is stated that concentration of loading, due to the shifting of contacting areas by the applied load, is the principal cause of failure. This shifting of loading may be due to poor cutting, warped gears or deflection, and, of the three causes, deflection is probably the worst offender, with warpage a poor second.

The importance of retaining the maximum area of contact between gear teeth which are rolling together cannot be overestimated. Special attention should be given to bearing mounting and design, with a special emphasis on improving the rigidity of the gear assembly and good tooth contacts under full loading.

Every possible effort should be made to increase the rigidity of the gear assembly by careful design and, if this is done, the results will be well worth while.

Gear materials are treated at length, together with their metallurgical properties, and various necessary tests are mentioned.

Recent Tractor Transmissions and Their Trend—*Otto R. Schoenrock, O.R.S. Engineering Co.*

CURRENT tractor transmissions are illustrated, and disclose the great variation in design. Materials of higher tensile strength will be used, and tractor units should be more compact in the future. This will reduce weight and lower the cost. There must be a continual striving for greater simplicity and elimination of parts.

Tractors should operate just as quietly as automobiles, which will be accomplished by better tooth forms, use of extreme-pressure lubricants and more accurate machining. More attention should be paid to the location of power take-off and belt pulley.

Higher engine speeds will require greater reduction in the transmission and a high-gear speed for road hauling will be required when pneumatic tires are used.

Servicing of tractor units by manufacturers will benefit the tractor user. There is need for standardization of tire and wheel diameters; also of wheel hubs and axle ends.

Tractors must be lighter, so that they are ideal for cultivating and similar operations. The additional weight required for plowing is to be obtained by attaching the plow directly to the tractor.

Some Thoughts on Present-Day Automobile Transmissions—*A. W. Frehse, Chevrolet Motor Co.*

A BRIEF description and an historical sketch of transmissions in general are given, illustrated by drawings of types commonly used in popular cars. Synchronizers and their operation are briefly described.

The paper in general deals more with helical gears, as this form of gear is now practically universally in use. A more exacting method for computing stresses in helical gears is offered, and it should apply to other forms of service and use as well. It points out how manufacturing variations limit the exactness of engineering work. This is not intended to be a wailing complaint, but to bring out the fact that exactness in engineering must be accompanied by exactness in manufacturing.

A very short and general description of manufacturing methods and the problems involved is given. Available steels best adapted to gear use are mentioned.

The paper closes with a view of the future use helical gears can be put to, especially in combinations of compound gearing. An indirect hint is made of two of the major problems connected with the use of compound helical gearing, which the designer should constantly keep in mind.

In conclusion, the statement is made that better transmissions could be built in the near future if the demand, with consideration of the increase in cost, should warrant their use.

Notes and Reviews

THESE items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a rule no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

Aerodynamic Theory Vol. IV

By William Frederick Durand. Published by Julius Springer, Berlin, 1935; 434 pp., illustrated. [A-1]

This book is the fourth in the series of six covering a general review of progress in this field, prepared under a grant of the Guggenheim Fund for the Promotion of Aeronautics. Volumes I, II and III have been reviewed previously in these columns.

Volume IV treats:

(a) Applied Airfoil Theory, by A. Betz;
(b) Airplane Body (Non-Lifting System) Drag and Influence on Lifting System, by C. Wieselsberger;
(c) Airplane Propellers, by H. Glauert; and
(d) Influence of the Propeller on Other Parts of the Airplane Structure, by C. Koning.

Technical Aerodynamics

By Karl D. Wood. Published by McGraw-Hill Book Co., Inc., New York and London, 1935; 330 pp., illustrated. [A-1]

This is a practical textbook on airplane performance and stability calculations, with emphasis on the basic principles. The author, assistant professor of mechanics of engineering at Cornell University, presents not only the fundamental theory of airplane flight, but also gives a comprehensive survey of the most pertinent technical data available on such topics as: sample computations for stability, performance computations, theoretical derivation and graphical presentation of equations for downwash, analytical computation of longitudinal stability, and so forth.

Tests of Nacelle-Propeller Combinations in Various Positions with Reference to Wings—VI—Wings and Nacelles with Pusher Propeller

By Donald H. Wood and Carlton Bioletti. N.A.C.A. Report No. 507, 1934; 31 pp., illustrated. Price, 10 cents. [A-1]

The Drag of Airplane Wheels, Wheel Fairings and Landing Gears —II—Nonretractable and Partly Retractable Landing Gears

By David Biermann and William H. Herrnstein, Jr. N.A.C.A. Report No. 518, 1935; 10 pp., illustrated. Price, 10 cents. [A-1]

Noise from Two-Blade Propellers

By E. Z. Stowell and A. F. Deming. N.A.C.A. Report No. 526, 1935; 9 pp., illustrated. Price, 5 cents. [A-1]

A Flight Investigation of the Spinning of the F4B-2 Biplane with Various Loads and Tail Surfaces

By N. F. Scudder and Oscar Seidman. N.A.C.A. Report No. 529, 1935; 22 pp., illustrated. Price, 10 cents. [A-1]

Wind-Tunnel Tests of a 10-Foot-Diameter Gyroplane Rotor

By John B. Wheatley and Carlton Bioletti. N.A.C.A. Report No. 536, 1935; 10 pp., illustrated. Price, 5 cents. [A-1]

Tests in the Variable-Density Wind Tunnel of Related Airfoils Having the Maximum Camber Unusually Far Forward

By Eastman N. Jacobs and Robert M. Pinkerton. N.A.C.A. Report No. 537, 1935; 9 pp., with tables and charts. Price, 5 cents. [A-1]

Altitude-Pressure Tables Based on the United States Standard Atmosphere

By W. G. Brombacher. N.A.C.A. Report No. 538, 1935; 14 pp., with tables and charts. Price, 5 cents. [A-1]

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NOTES AND REVIEWS

Continued

ENGINES

A Comparison of Fuel Sprays from Several Types of Injection Nozzles

By Dana W. Lee. N.A.C.A. Report No. 520, 1935; 38 pp., illustrated. Price, 25 cents. [E-1]

Some Effects of Injection Advance Angle, Engine-Jacket Temperature, and Speedon Combustion in a Compression-Ignition Engine

By A. M. Rothrock and C. D. Waldron. N.A.C.A. Report No. 525, 1935; 15 pp., illustrated. Price, 10 cents. [E-1]

The Effect of Water Vapor on Flame Velocity in Equivalent Co-O_2 Mixtures

By Ernest F. Fiock and H. Kendall King. N.A.C.A. Report No. 531, 1935; 6 pp., illustrated. Price, 5 cents. [E-1]

The Soap-Bubble Method of Studying the Combustion of Mixtures of CO and O_2

By Ernest F. Fiock and Carl H. Roeder. N.A.C.A. Report No. 532, 1935; 14 pp., illustrated. Price, 5 cents. [E-1]

Distribution and Regularity of Injection from a Multicylinder Fuel-Injection Pump

By A. M. Rothrock and E. T. Marsh. N.A.C.A. Report No. 533, 1935; 12 pp., with charts. Price, 10 cents. [E-1]

Zündung und Flammenbildung bei der Diesel-Brennstoff-Einspritzung

By Otto Holfelder. *VDI-Forschungsheft* 374, September-October, 1935. Published by VDI-Verlag, Berlin, Germany. 25 pp.; 51 illustrations. [E-1]

To obtain fundamental knowledge on the phenomena following the ignition and burning of fuel sprays injected into heated air under Diesel engine conditions, a new test apparatus was developed and an investigation carried out with it.

Fuel was injected into a bomb containing air heated by compression. The bomb was fitted with windows, through which a slow motion camera photographed the entire course of ignition and combustion. At the same time, temperatures and pressures were recorded. Different types of fuel jet and various fuels were investigated. Through a special construction, the bomb was made to give results similar to those obtainable in an ante-combustion chamber type engine. The results obtained are said to be closely applicable to actual engine conditions.

Phenomènes de Combustion dans les Moteurs à Injection et à Carburation

By Max Serruys. Published in *Journal de la Société des Ingénieurs de l'Automobile*, June, July, August, 1935, p. 247. [E-1]

Using a modified Farnboro indicator and an optical indicator connected directly to the combustion chamber, the author has obtained pressure-time diagrams of detonating combustion from which he concludes that the pressure increase during such combustion is extremely violent, initially localized, is produced in less than 1/10,000 s., is accompanied by high local temperature increase, and propagates itself in pressure waves, the velocity and frequency of which he has measured. Based on his observations also is a theory of the origin of detonation here expounded and the conclusion that combustion in injection engines tends to begin with detonation.

Biegungsschwingungen von Kurbelwellen, insbesondere bei Schweren Schwungrädern

By Walter Benz. Published in *Automobiltechnische Zeitschrift*, Aug. 20, 1935, p. 405. [E-1]

The special case of torsional vibration of crankshafts here considered is that of crankshafts with especially heavy flywheels. Results of an experimental investigation are reported and a method of theoretical calculation is discussed.

Versuche mit Koksartigen Brennstoffen in Gaserzeugern für Mittlere Kraftfahrzeuge

By H. Meuth. Published in *Automobiltechnische Zeitschrift*, Sept. 25, 1935, p. 447. [E-1]

Predicting that within a period of from 10 to 15 years all Germany's liquid fuel will be produced from domestic raw products, the author proposes that until this is achieved means be provided for using solid fuels directly in automotive vehicles. This article reports the development and testing of a gas-producer unit for passenger and light delivery cars.

(*Continued on page* 46)


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Speed of Cost Reduction can be Speeded-up by Speeding-up Replacement of old equipment with more Modern Installations.
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NOTES AND REVIEWS

Continued

MATERIAL

An Investigation of the Compressive Strength Properties of Stainless Steel Sheet-Stringer Combinations

Prepared by E. H. Schwartz and C. G. Brown. Air Corps Technical Report No. 4010; November 30, 1934; 78 pp., illustrated. [G-1]

Analytical Determination of Optimum Pitch-Depth Ratios in Corrugated Sheet Design

Prepared by E. E. Blount. Air Corps Technical Report No. 4086; June 15, 1935; 3 pp., with charts. [G-1]

The Column Properties of Corrugated Aluminum Alloy Sheet

Prepared by Capt. C. F. Greene and C. G. Brown. Air Corps Technical Report No. 3227; June 15, 1935; 19 pp., illustrated. [G-1]

Les Applications du Graphite Dit Colloidal, Notamment au Point de Vue de la Lubrification des Moteurs

By G. Delanghe. Published in *Le Génie Civil,* July 20, 1935, p. 61. [G-1]

The processes by which colloidal graphite lubricants are manufactured from natural graphite, notably that of Madagascar, constitute the chief topic of this article. Introducing it is a discussion of the general nature and action of such lubricants, and supplementing it a more specific treatment of graphite in internal-combustion engines.

Standard Methods for Testing Petroleum and Its Products

Published by The Institution of Petroleum Technologists, London, Third Edition, 1935; 228 pp. [G-3]

This volume has been received for use in the Society's library.

A.S.T.M. Standards on Petroleum Products and Lubricants Prepared by Committee D-2 on Petroleum Products and Lubricants

Published by the American Society for Testing Materials, Philadelphia, September, 1935; 358 pp. [G-3]

Each year A.S.T.M. Committee D-2 on Petroleum Products and Lubricants sponsors the publication under one cover of all A.S.T.M. standards pertaining to petroleum. The current edition, 1935, contains 57 test methods, six specifications and two lists of standardized definitions of terms, all of this material being given in its latest approved form.

1935 Supplement to Book of A.S.T.M. Standards

Published by the American Society for Testing Materials, Philadelphia, 1935; 208 pp. [G-3]

This pamphlet comprises the second Supplement to the 1933 Book of A.S.T.M. Standards and contains 36 standards adopted or revised by letter ballot of the Society on September 3, 1935. Eighteen of the standards appearing in this volume are new standards, the remaining eighteen are replacements of existing standards.

MISCELLANEOUS

Proceedings of the Institution of Automobile Engineers, Volume XXIX

Published by the Institution, London, 1935; 810 pp., and illustrations. [H-1]

The Proceedings of the 1934-35 session of the Institution of Automobile Engineers is now available.

La Conservation de la Précision d'Origine des Banc des grosses Machines-Outils

By L. Prévost. Published in *La Technique Moderne,* Sept. 1, 1935, p. 573. [H-5]

Due to temperature effects, machine-tool installations are said commonly to lose their original precision. Two sources of deformation are cited, thermal expansion and modifications of the equilibrium of internal forces exerted in castings. To the latter, and to the manner in which they may be obviated by correct foundry practice, this article is mainly devoted.

PASSENGER-CAR

Le Salon de 1935

By C. Faroux. Published in *La Vie Automobile,* Sept. 25, 1935, p. 353. [L-1]

Progress without revolution is said to be the keynote of the 1935 Paris show, in which the freak has given place to the product of common

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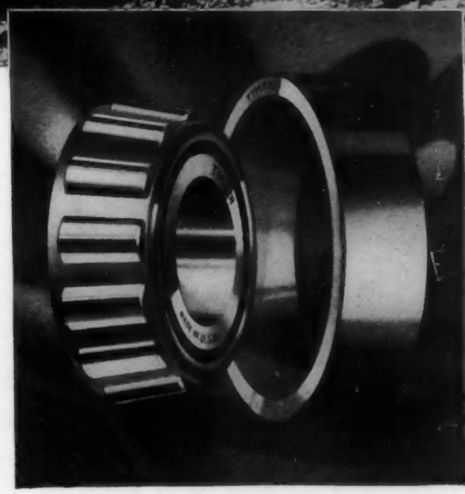
Mt. Robson and Berg Lake, Jasper National Park, Alberta.



NOTES AND REVIEWS

Concluded

sense. Increasing compression ratios and engine speeds, more wide-spread use of independent wheel suspensions and hydraulic brakes, much special progress in transmissions, ever larger tires, and streamlined bodies in which efficiency and aesthetics are wed—these are the outstanding developments

Vitesse, Confort, Économie

By Henri Petit. Published in *La Vie Automobile,* Sept. 25, 1935, p. 359. [L-1]

An interesting table here presented shows the speeds, maximum and average, and fuel consumption of a number of makes of cars during the years from 1911 to 1935. The article analyzes the factors contributing to the decided increase in average speeds during the last two years, under the headings of highways, traffic regulations and automobile design.

Die Entwicklung der Kraftfahrzeuge für die Reichsautobahnen

By A. Liese. Published in *Automobiltechnische Zeitschrift,* Sept. 25, 1935, p. 445. [L-1]

Important in the motorization of Germany is the construction of automobile express highways. This article analyzes the increase in average speeds that will be permitted by these highways and the changes in automotive design that such sustained high speeds will impose.

Étude des Bruits des Voitures Automobiles

By Charles Brull. Published in *Journal de la Société des Ingénieurs de l'Automobile,* June, July, August, 1935, p. 259. [L-1]

One of the most promising paths for automobile noise reduction is to deal with those noises arising from the contact of the vehicle with the ground, which involves a study of tire treads, highway surfaces and the adaptation of the one to the other. This is the author's conclusion to his practical article on automobile noise, during which he lists in scrupulous detail the sources of automobile noise, treats of their varying importance with speed, discusses sound insulation and absorption in the body and the nature of sound and human sensitivity to it, and reports some measurements of automobile noise.

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Starting-Motor (Standard Mountings)
Electric Auto-Lite Co.
Starting Motors
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Timken Roller Bearing Co.
Timken Steel & Tube Co.
Steel, Carbon
Timken Roller Bearing Co.
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Republic Steel Corp.
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Bundy Tubing Co.
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Eaton Mfg. Co.
Hobbs Mfg. Co.
National Lock Washer Co.
Philadelphia Steel & Wire Corp.
Positive Lock Washer Co.
Shakeproof Lock Washer Co.
Thompson-Bremer & Co.
Washburn Co.
Washers, Spring
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Beall Tool Co.
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Eaton Mfg. Co.
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National Lock Washer Co.
Philadelphia Steel & Wire Corp.
Positive Lock Washer Co.
Washburn Co.
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DECEMBER 1935

S·A·E JOURNAL

30th ANNIVERSARY
YEAR 1935

THE SOCIETY OF
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Where new TRUCK-MILES *are born*

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